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MEMBERSHIP OF THE ACADEMY

April 30, 1942

ABBREVIATIONS: The following abbreviations for institutions have been used:

U. of K.: University of Kansas.
K. S. C.: Kansas State College of Agriculture and Applied Science.
K. S. T. C.: Kansas State Teachers College.
F. H. K. S. C.: Fort Hays Kansas State College.
H. S.: High School.
Jr. H. S: Junior High School.
Jr. Col.: Junior College.

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Anderson Memorial Library, 1940, College of Emporia, Emporia.
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*Hoyle, W. L., M.S., 1939, Stillwell.
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*Argentine Biol. Sc. Club of K.C., 1939, Gladys Beck, Sponsor, Wyandotte H.S., Kansas City.
*Ben Franklin Club, 1935, Liberty Memorial H.S., Lawrence.
H.S. Science Club, 1941, Cherryvale, Daniel Simpkin, Sponsor.
Dellinger Jr. Science Club, College High School, May Hare, Sponsor, Pittsburg.
Galena Jr. H. Science Club, 1941, Dale Stonecipher, Sponsor, Galena.
*Garden City School Science Club, 1942, Garden City.
*Girard High School Science Club, 1938, W. V. McFerrin, Sponsor, Girard.
Holiday Jr. Sc. Club, 1941, Topeka H.S., Clarence L. Miller, Sponsor, Topeka.
*Independence Gen. Sc. Club, 1938, Parley W. Dennis, Sponsor, Independence.
Iola Jr. Science Club, 1938, 1941, Carl G. Isles, Sponsor, Iola.
Junction City H.S. Sc Club, 1934, H. R. Callhan, Sponsor, Junction City,
*Kaolin Science Club, 1941, Ernest Larson, Sponsor, Clay Co. Com. H.S., Clay Center.
*Kensington Science Club, 1942, Helen Holman, Sponsor, Kensington.
*Lawrence Junior H.S. Science Club, 1932, Edith Beach, Sponsor, Lawrence.
Madison H.S. Science Club, 1939, E. L. Kirkpatrick, Sponsor, Madison.
*Manhattan H.S. Sc. Club, 1938, Ralph Rogers, Donald Parrish, & Robt. Boles, Sponsors, Manhattan.
McCune H.S. Science Club, Kenneth McClure, Sponsor, McCune.
Nature Club, 1941, J. A. Wimmer, Sponsor, Uniontown H.S., Uniontown.
*Pittsburg H.S. Jr. Academy, 1938, Nell K. Davis, Sponsor, Pittsburg.
*Retorts Science Club, 1939, J. C. Hawkins, Sponsor, Merriam.
*Salina Jr. Academy of Science, 1942, High School, Salina.
*Seaman Science Club, 1939, Laura Greene, Sponsor, Seaman H S., Topeka.
Sherman Jr. High Science Club, 1941, Hutchinson, Alex Richards, Sponsor.
Taxidermy Club, 1938, Russell Davee, Sponsor, C.C.C H S., Columbus.
*Wichita East High Science Club, 1934, J. A. Brownlee, Sponsor, 340 N. Ash, Wichita.
Yates Center H.S. Sc. Club, 1941, E. L. Kirkpatrick, Sponsor, Yates Center.

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*Wetmore, Alexander, 1935, Ph.D., U.S. Nat. Museum, Washington, D.C.
*Wheeler, Raymond H., Ph.D., 1936, Prof. and Head Dept. Psych., U. of K., Lawrence.
*White, D. Stephen, Stud., 1942, Box 901, Winfield, or Pretty Prairie.
*White, Otis, M.S., 1939, 408 S. Volutsia, Wichita.
White, Roger F., B.S., 1940, Address Unknown.
*Whitla, Raymond E., A.B., 1937, Mountain Home, Ark.
Whitney, Lester V., Ph.D., Assoc. Prof. of Physics and Math., R.R. 8, Springfield, Mo.
*Wichita City Library, 1932, Wichita. (Miss Ruth Hammond)
*Wichita University Library, 1939, Univ. of Wichita, Wichita
*Wilbur, Donald A., M.A., 1934, Assoc. Prof. Ent., K.S.C., Manhattan.
*Wilkie, Grace, M.A., 1940, Dean of Women, Head of Home Ec. Dept., Univ. of Wichita.
Winburn, Temple F., M.S., 1940, 1204 Fremont, Manhattan.
Wimmer, Edward J., Ph.D., 1928, Prof. of Zool., K.S.C., Manhattan.
Wismer, Nettie M., M.S., 1932, 1939, 342 Johnson Ave., Lawrence.
*Witherspoon, Ward, M.A., 1936, Jr. College, Coffeyville.
Wolfson, Charles, Ph.D., Instr. Anat. Dept., U. of K., Lawrence.

*Wood, C. S., M.S., 1940, Pratt Junior College, Pratt.
*Wood, Robert E., M.S., 1930, Chem., Liberty Memorial H.S., Lawrence.
*Woodard, Parke, M.D., 1939, Assoc. Prof. Physiol., U. of K., Lawrence.
*Wooster, L. D., Ph.D., 1924, Zoology Dept., F.H.K.S.C., Hays.
*Wooster, Martha, Student Clinician, 1942, 212 W. 1st, Hays.
Yantzi, Millard F., M.S., 1941, Grad. Stud , Bact. Dept , K.S.C., or 2232 Quindaro Blvd., Kansas City.
*Yoder, Maurice A., M S., 1938, Hesston.
*Yoos, Charles, Ph.M., 1942, Registrar, Psyc. Instr., Chanute Jr. Col., Chanute.
*Yost, T. H., B.S., 1942, State Weed Supervisor, State House, Topeka.
*Young, H. D., B.S., 1935, 1940, Assoc. Chem., U.S.D.A , 1204 Fremont, Manhattan.
*Young, Roger L., 1938, 914 Kentucky St., Lawrence.
*Younkin, Russell J., 1940, 2116 West Cumberland, Knoxville, Tenn.
*Zerger, Paul, A.B., 1940, 2110 11th St., Great Bend, or Moundridge.
*Zinszer, Harvey A., Ph.D., 1930, Prof. Phys. and Astr., F.H.K.S.C., Hays.
*Zinszer, Richard H., Ph.D., 1931, Engr. Union Oil, R. 2, Box 273 C, Santa Maria, Calif.
*Zinszer, Wm Karl, M.S., 1938, 1125 Ramona, Palo Alto, Calif.

NECROLOGY

The Academy announces with regret the deaths of the following members:

MALCOLM J. BRUMWELL. Lieutenant Brumwell was born at Sarles, North Dakota on August 1, 1911. He died on December 14, 1941, of injuries received while in combat on that fateful day of December 7, 1941 at Hickam Field, Hawaii. After graduation from high school, Lieutenant Brumwell enlisted in the United States Army, served there three years and attained the rank of second lieutenant. In the fall of 1935, he entered the University of Kansas, majoring in vertebrate zoology. He was an assistant in Dyche Museum during his undergraduate career, and, upon receiving his bachelor's degree in 1939, became an assistant instructor in the department of zoology at the University of Kansas. His active career with the Academy began in 1939. In August, 1941, he was called back into active military service as he had maintained a reserve commission since leaving the army.

J. WHIT EBY. Mr. Eby was born in 1875 and was graduated from Ottawa University in 1901. He taught sciences in the Owatona (Minnesota) High School for several years and then entered the law school of the University of Kansas. Most of his mature years were spent as a banker at Howard, Kansas. His continued interest in scientific work, however, was shown by the fact that he was a life member of the Academy from 1903 until his death which occurred at Halstead, Kansas, on June 1, 1941.

CLARENCE EDMUND RARICK. President Rarick was born March 17, 1879, in Glenn Elder, Kansas. He died August 1, 1941, at his home in Hays, Kansas. He was educated at the United States Military Academy, Kansas Wesleyan University and at the Universities of Colorado and Kansas. He served for some years as teacher and administrator in Kansas public schools, and, in 1919, became professor of rural education at the Fort Hays Kansas State College. In 1933 he became president of this state institution and served in that capacity until his death in 1941.

JOHN ERIC WELIN. Professor Welin was born in Stockholm, Sweden, June 11, 1865. He died October 23, 1941 at his home in Lindsborg, Kansas. His family moved to America in 1870, and by 1874 had established permanent residence in Lindsborg. Professor Welin was educated at Bethany Academy (Lindsborg), Augustana College (Illinois) and the University of Kansas. After a year's teaching experience, he became a teacher of natural sciences at Bethany College in 1891, and, for nearly fifty years, served that institution with fidelity and distinction. As the field of the natural sciences grew, his attention was directed more especially to the fields of chemistry, physics and astronomy, with especial attention directed to analytical chemistry. Professor Welin was a life member of the Kansas Academy of Science, and, in point of service, he was one of its oldest members, having first joined the Academy in 1889. His active career at Bethany College was terminated by illness in 1936; the following year he became "Professor Emeritus", a title he held at the time of his death in 1941.

OFFICERS OF THE ACADEMY, 1869-1943

Year	President	First Vice-President	Second Vice-President	Secretary	Treasurer
1869	B. F. Mudge	J. S. Whitman		J. D. Parker	F. H. Snow
1870	B. F. Mudge	J. S. Whitman		J. D. Parker	F. H. Snow
1871	John Fraser	B. F. Mudge		J. D. Parker	F. H. Snow
1872	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F H. Snow
1873	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F. H. Snow
1874	F. H. Snow	J. A. Banfield	J. D. Parker	John Wherrell	R. J. Brown
1875	F. H. Snow	B. F. Mudge	J. D. Parker	John Wherrell	R J. Brown
1876	F. H. Snow	B. F. Mudge	J. H. Carruth	Joseph Savage	R. J. Brown
1877	F. H. Snow	B. F. Mudge	J. H. Carruth	Joseph Savage	R. J. Brown
1878	F. H. Snow	B. F. Mudge	J. H. Carruth	E. A. Popenoe	R. J. Brown
1879	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1880	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1881	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popenoe	R J. Brown
1882	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1883	A. H. Thompson	J. R. Mead	G. E. Patrick	E. A. Popenoe	R. J. Brown
1884	R. J. Brown	F. H. Snow	Joseph Savage	E. A. Popenoe	A. H. Thompson
1885	R. J. Brown	E. L. Nichols	G. H. Failyer	E. A. Popenoe	A. H. Thompson
1886	E. L. Nichols	J. D. Parker	N. S. Goss	E. A. Popenoe	I. D. Graham
1887	J. D. Parker	J. R. Mead	E. H. S. Bailey	E. A. Popenoe	I. D. Graham
1888	J. R. Mead	E. H. S. Bailey	T. H. Dinsmore, Jr.	E. A. Popenoe	I. D. Graham
1889	T. H. Dinsmore, Jr.	E. H. S. Bailey	G. H. Failyer	E. A. Popenoe	I. D. Graham
1890	G. H. Failyer	D. S. Kelly	F. W. Gragin	E. H. S. Bailey	I. D. Graham
1891	Robert Hay	F. W. Cragin	O. C. Charlton	E. H. S. Bailey	F. O. Marvin
1892	E. A. Popenoe	F. O. Marvin	Mrs. N. S. Kedzie	E. H. S. Bailey	D. S. Kelly
1893	E. H. S. Bailey	J. T. Willard	E. B. Knerr	A. M. Collete	D. S. Kelly
1894	L. E. Sayre	I. D. Graham	J. L. Howitt	E. B. Knerr	D. S. Kelly
1895	Warren Knaus	I. D. Graham	S. W. Williston	E. B. Knerr	D. S. Kelly
1896	D. S. Kelly	S. W. Williston	D. E. Lantz	E. B. Knerr	L. E. Sayre
1897	S. W. Williston	D. E. Lantz	A. S. Hitchcock	E. B. Knerr	J. W. Beede
1898	D. E. Lantz	C. S. Parmenter	L. C Wooster	E. B. Knerr	J. W. Beede
1899	E. B. Knerr	A. S. Hitchcock	J. R. Meade	D. E. Lantz	J. W. Beede
1900	A. S. Hitchcock	E. Miller	J. C. Cooper	D. E. Lantz	J. W. Beede
1901	E. Miller	J. C. Cooper	L. C. Wooster	D E. Lantz	E. C. Franklin
1902	J. T. Willard	Edward Bartow	J. A. Yates	G. P. Grimsley	E. C. Franklin
1903	J. C. Cooper	Edward Bartow	J. A. Yates	G. P. Grimsley	Alva J. Smith
1904	Edward Bartow	L. C. Wooster	B. F. Eyer	G. P. Grimsley	Alva J. Smith
1905	L. C. Wooster	F. W. Bushong	W. A. Harshbarger.	J. T. Lovewell	Alva J. Smith
1906	F. O. Marvin	B. F. Eyer	J. E. Welin	J. T. Lovewell	Alva J. Smith
1907	J. A. Yates	E. Haworth	F. B. Dains	J. T. Lovewell	Alva J. Smith
1908	E. Haworth	F. B Dains	J. M. McWharf	J. T. Lovewell	Alva J. Smith
1909	F. B. Dains	J. M. McWharf	Alva J. Smith	J T. Lovewell	F. W. Bushong
1910	F. B. Dains	J M. McWharf	Alva J. Smith	J. T. Lovewell	F. W. Bushong
1911	J. M. McWharf	Alva J. Smith	J. E Welin	J. T. Lovewell	F. W. Bushong
1912	F. W. Bushong	Alva J. Smith	J. E. Welin	J. T. Lovewell	L. D. Havenhill
1913	Alva J. Smith	W. A. Harshbarger.	J. A. G. Shirk	J. T. Lovewell	L. D. Havenhill
1914	W. A. Harshberger.	J. A. G. Shirk	J. E. Todd	J. T. Lovewell	L. D. Havenhill
1915-1916	J. A. G. Shirk	J. E. Todd	F. U. G. Agrelius	J. T. Lovewell	L D. Havenhill
1916-1917	J. E. Todd	F. U. G. Agrelius	L. D. Havenhill	W. W. Swingle	W.A.Harshbarger
1917-1918	F. U. G. Agrelius	L. D. Havenhill	B. M. Allen	W. W. Swingle	W.A.Harshbarger
				H. W. Swingle	
				Guy West Wilson	
1918-1919	L. D. Havenhill	R. K. Nabours	B. M. Allen	Guy West Wilson	F. C. Bruchmiller
1919-1920	R. K. Nabours	B. M. Allen	O. P. Dellinger	E. A. White	L. D. Havenhill
1920-1921	O. P. Delinger	Roy Rankin	W. P. Hays	E. A. White	L. D. Havenhill
1921-1922	Roy Rankin	R. K. Nabours	W. R. B. Robertson.	E. A. White	L. D. Havenhill
1922-1923	R. K. Nabours	H. P. Cady	H. H. Nininger	E. A. White	L D. Havenhill
1923-1924	H. P. Cady	H. H. Nininger	J E. Ackert	E. A. White	L. D. Havenhill
1924-1925	H. H. Nininger	J. E. Ackert	F. U. G. Agrelius	E. A. White	L. D. Havenhill
1925-1926	J. E. Ackert	H. M. Elsey	W. M. Goldsmith	E. A. White	L. D. Havenhill
1926-1927	H. J. Harnly	Mary T. Harman	L. D. Wooster	E. A. White	L. D. Havenhill
1927-1928	Mary T. Harman	L. D Wooster	W. B. Wilson	E. A. White	L. D. Havenhill
1928-1929	L. D. Wooster	W. B. Wilson	Hazel E. Branch	G E. Johnson	L. D. Havenhill
1929-1930	W. B. Wilson	Hazel E. Branch	W. M. Goldsmith	G. E Johnson	R. Q. Brewster
1930-1931	Hazel E. Branch	Roger C. Smith	W. H. Matthews	G. E. Johnson	R. Q. Brewster
1931-1932	Roger C. Smith	W. J. Baumgartner.	J. W. Hershey	G. E. Johnson	R. Q. Brewster
1932-1933	Robert Taft	J. W. Hershey	W. H. Matthews	G. E Johnson	H. A. Zinszer
1933-1934	J. W. Hershey	W. H. Matthews	E. A. Marten	G. E. Johnson	H. A. Zinszer
1934-1935	W. H. Matthews	E. A Marten	W. J. Baumgartner.	G. E. Johnson	H. A. Zinszer
				F. C. Gates.	
1935-1936	W. J. Baumgartner.	L. Oncley	H. H. Hall	Roger C. Smith	H. A. Zinszer
1936-1937	L. Oncley	G. A. Dean	W. H. Schoewe	Roger C. Smith	H. A. Zinszer
1937-1938	G. A. Dean	W. H. Schoewe	H. H. Hall	Roger C. Smith	H. A. Zinszer
1938-1939	W. H. Schoewe	H. H. Hall	E. O. Deere	Roger C. Smith	H A. Zinszer
1939-1940	H. H. Hall	E. O. Deere	F. C. Gates	Roger C. Smith	H. A. Zinszer
1940-1941	E. O. Deere	F. C. Gates	R. H. Zinszer	Roger C. Smith	H. A. Zinszer
1941-1942	F. C. Gates	R. H. Wheeler	H. A. Zinszer	John C. Frazier	F. W. Albertson
1942-1943	R. H. Wheeler	H. A. Zinszer	L. D. Bushnell	John C. Frazier	F. W. Albertson

NOTE.—Previous to 1931-'32 the secretary was also editor of these *Transactions*. From 1931 until 1941, F. C. Gates was editor.

PROGRAM OF THE SEVENTY-FOURTH ANNUAL MEETING, HAYS, KANSAS

THURSDAY, MARCH 26

4:00 p. m. Executive Council Meeting, Room 306, Science Hall.

5:00 p. m. to 9:30 p. m. Registration, Picken Hall.

7:30 p. m. Public Lecture, Dr. A. C. Kinsey, Indiana University, Subject: "Bug Hunting in Mexico." Illustrated. Picken Hall Auditorium.

9:00 p. m. General Reception, Social Building.

FRIDAY, MARCH 27

8:00 a. m. to 5:00 p. m. Registration, Science Hall, Room 107.
Exhibits, Science Hall, Room 201.

9:00 a. m. to 10:25 a. m. Sectional Meetings.
Botany, Science Hall, Room 309.
Junior Academy, Science Hall, Class A, Room 301; Class B, Rooms 205, 206.
Psychology, Science Hall, Room 202.
Zoology, Science Hall, Room 210.

10:30 a. m. to 10:55 a. m. First General Business Session.
President Gates Presiding. Picken Hall Auditorium.

1. Announcements of plans for 1942 by President-Elect R. H. Wheeler.
2. Other business.

11:00 a. m. to 12:00 noon. Special Paper for Academy Members entitled "Studies in Human Behavior," by Dr. A. C. Kinsey, Indiana University. Illustrated. Picken Hall Auditorium.

12:00 noon Meeting of all 1942 Committees.

1:00 p. m. Sectional Meetings.
Botany, Science Hall, Room 309.
Geology, Science Hall, Room 305.
Chemistry, Science Hall, Room 113.
Physics, Science Hall, Room 110.
Psychology, Science Hall, Room 202.
Zoology, Science Hall, Room 210.

3:30 p. m. to 6:00 p. m. Mathematics Registration. Science Hall, Room 107.

6:15 p. m. Academy Banquet. College Cafeteria. Dr. R. H. Wheeler, Toastmaster.

Address of Welcome, Dr. L. D. Wooster, President, Fort Hays Kansas State College.

8:00 p. m. Open meeting, Presidential Address: "Succession." Dr. F. C. Gates. Picken Hall Auditorium.

SATURDAY, MARCH 28

8:00 a. m. Geology Field Trip to the Fossil Chalk Beds. Meet in Science Hall, Room 210.
8:00 a. m. General Business Session. Picken Hall Auditorium.
10:00 a. m. Sectional Meetings.
College Students Section, Science Hall, Room 113.
The American Association of University Professors. Science Hall, Room 202.
Biology Teachers, Science Hall, Room 309.
Mathematical Societies, Science Hall, Room 309.
12:30 p. m. Luncheon meeting of the 1942 Executive Council. Function Room, College Cafeteria.
1:45 p. m. University Professors, Science Hall, Room 202.
2:00 p. m. Mathematical Societies, Science Hall, Rooms 209 and 210.

BOTANY

Chairman, S. M. Pady

FRIDAY, MARCH 27

9:00 a. m. to 10:25 p. m., Science Hall, Room 309

1. Kansas Botanical Notes, 1941. F. C. Gates, K. S. C. 15 min.
2. Studies Pertaining to the Life History of *Specularia perfoliata*. J. A. Trent, K. S. T. C., Pittsburg. Lantern. 8 min.
3. Occurrence and Habits of *Aplectrum hyemale* in Kansas Woods. W. C. Stevens and Florence E. Dill, U. of K. Lantern. 10 min.
4. A Remarkable Variation in the Inflorescence of *Helianthus mollis*. W. C. Stevens. Lantern. 7 min.
5. A Study of the Woody Plants along the Streams which cross Ellis County, Kansas. Sherman B. Griswold, Newton High School. Lantern. 10 min.
6. Observations on *Melampsorella* in the Western States in 1941. S. M. Pady, Ottawa U. Lantern. 10 min.
7. A Study of Equine Sporotrichosis. M. J. Twiehaus and H. J. Peppler, K. S. C. Lantern. 10 min.
8. The Heat Resistance of *Streptococcus thermophilus* grown in Association with Caseolytic Bacteria. H. J. Peppler, K. S. C. Lantern. 10 min.
9. Prairie Studies in West Central Kansas, 1941. F. W. Albertson, F. H. K. S. C. Lantern. 10 min.

1:00 p. m. to 3:30 p. m.

10. The Seed Yield of Native Prairie Plants in West Central Kansas. Ray Brown, F. H. K. S. C. Lantern. 15 min.
11. Indications of Hail Resistance Among Varieties of Winter Wheat. Louis P. Reitz, K. S. C. 10 min.
12. Effect of Harvest Date and Heredity Upon the Dormant Period in Varieties of Winter Wheat. H. C. Traulsen and Louis P. Reitz, K. S. C. 10 min.

13. Estimating the Yield of Blue Grama Grass Seed. Donald R. Cornelius and Newell C. Melcher. Soil Conservation Nursery, Manhattan. 10 min.
14. The Effect of Different Intensities of Grazing on Three Varieties of Hard Winter Wheat. Raymond F. Roemer, F. H. K. S. C. Lantern. 10 min.
15. Evaluation of Species of Prairie Grasses as Interplanting Ground Covers on Eroded Soils. Ivan L. Boyd, Soil Conservation Service, Baldwin. Lantern. 10 min.
16. A Study of the Rhizomes of Some Perennial Grasses During Winter Dormancy. Leo Schraeder, F. H. K. S. C. Lantern. 10 min.
17. The Root System of Hoary Cress, *Lepidium draba* L. John C. Frazier, K. S. C. Lantern. 8 min.
18. Establishing Stands of Native Grasses on Land Retired from Cultivation: A Preliminary Report. Andrew Riegel, F. H. K. S. C. Lantern. 10 min.
19. Dormancy Breaking Followed with Culture Solution. Clinton C. McDonald, U. of Wichita. 5 min.
20. Change in the Degree of Pollution in the Smoky Hill River Near Lindsborg. Birger Olson, Bethany Col.
21. The Effect of Different Intensities and Time of Grazing and the Degree of Dusting Upon the Vegetation of Range Land in West Central Kansas. Lawrence E. Cressler, Wichita. (By title).
22. The Relation of Depth of Planting to the Morphology of the Wheat Seedling. William A. Lunsford, K.S.C. (By title).
23. Anatomy of the Dandelion, *Taraxacum officinale* Weber. L. J. Gier and Ralph M. Burress, Wm. Jewell Col., Liberty, Mo. (By title).

CHEMISTRY

Chairman, Leonard C. Kreider

FRIDAY, MARCH 27

1:00 to 3:30 p.m., Science Hall, Room 113

1. Products Obtained from the Kentucky Coffee Bean Tree. Lawrence Oncley and Dwight Couch, Southwestern Col. 10 min.
2. Addition Agents in the Electro-deposition of Lead from Solutions of Lead Nitrate. Robert Taft and John K. Fincke. Lantern. 10 min.
3. Animal Life in Synthetic Mixtures of N_2 and O_2 with Low and Medium Relative Humidity. J. Willard Hershey, McPherson Col. Lantern. 5 min.
4. Separation of Sulfurous Acid from Dried Apricots. Sister Mary Grace Waring, Marymount Col. Lantern. 8 min.
5. A Method for the Determination of the Hardness of Milk Curd. Arthur W. Barton, F. H. K. S. C. 10 min.
6. Perbromates and Perbromic Acid. Lawrence Oncley and Harry Pinnick, Southwestern Col. 10 min.
7. Rotational Relationships of Alkyl Glucosides. Leonard C. Kreider, Bethel Col. Lantern. 8 min.
8. Crystalline Forms of Osazones of Lactose, Maltose, Glucose and Galactose. Sister Mary Grace Waring and Mary Still, Marymount Col. Lantern. 8 min.

9. Determination of Iodide in Stabilized Iodized Salt: I. Reducing Type Stabilizers. L. A. Enberg, The Carey Salt Company. Lantern. 10 min.
10. The Magnesium Content of Rocks of the Upper Cretaceous System of Ellis County, Kansas. Robert Funston and Wilbert Chappell, F. H. K. S. C. 5 min.
11. Floating Baroscopes, Barometers and Vacuum Gauges. Frank E. E. German, U. of Colo. Demonstration. 8 min.

GEOLOGY

Chairman, George M. Robertson

FRIDAY, MARCH 27

1:00 p. m. to 5:00 p. m., Science Hall, Room 305

1. The Occurrence of *Eucastor tortus* Leidy in the Tertiary of Kansas. Claude W. Hibbard, U. of K. 8 min.
2. A New Squirrel from the Pliocene of Kansas. Claude W. Hibbard, U. of K. 5 min.
3. Pliocene Mammal Tracks in Graham County, Kansas. George F. Sternberg and George M. Robertson, F. H. K. S. C. Lantern. 10 min.
4. Crinoidal Material from the Kansas Permian. Frank Byrne and Evelyn Seeberger, K. S. C. 10 min.
5. A New *Fundulus* from the Pliocene of Kansas. George M. Robertson, F. H. K. S. C. Lantern. 5 min.
6. An Example of Cross bedding in the Fort Riley Limestone. Carl Barnhart, Wichita. 5 min.
7. Best Oil Production Along Zones of Megashearing: Two Promising Trends in Western Kansas and Nebraska. Ashton Keith, Kansas City, Mo. Lantern. 15 min.
8. Kansas Amber. Walter H. Schoewe, U. of K. 5 min.
9. The State Geological Survey and National Defense. Walter H. Schoewe, U. of K. 5 min.
10. A Review of North American Pennsylvanian Corals. R. M. Jeffords, U. of K. Lantern. 10 min.
11. *A Caninia* from the Lower Carboniferous of New Mexico. R. M. Jeffords, U. of K. Lantern. 5 min.

Formal papers to be followed by informal reports on research in progress by members of the geology section.

SATURDAY, MARCH 28

Field trip to the Niobrara chalk exposures. 8 a. m. to 4 p. m. Meet in Room 210, Science Hall.

JUNIOR ACADEMY OF SCIENCE OF KANSAS

President, John Michener, Jr., Wichita
Secretary, Ray Throckmorton, Manhattan
Chairman, L. D. Wooster, F. H. K. S. C.

FRIDAY, MARCH 27

8:30 a.m. to 12:00 noon, Science Hall
Class A, Room 301. Class B, Rooms 205 and 206
Mimeographed copies of the program to be distributed at the meeting.

PHYSICS

Chairman, R. F. Miller, acting

FRIDAY, MARCH 27

1:00 p.m. to 3:30 p.m., Science Hall, Room 110

1. Spectrophotometric Determination of the Vitamin Content of the Kentucky Coffee Bean. W. B. Plum, L. O. Oncley and R. Stephen White, Southwestern Col. Lantern. 15 min.
2. A Self-sustaining Electronichord. W. D. Bemmels, Ottawa U. Lantern. **5 min.**
3. Absolute Dimensions and Masses of Eclipsing Binary Stars. Stanley Alexander, Washburn. Lantern. 15 min.
4. Construction of a Liquid Filter Cell for Ultraviolet Stellar Photography. Philip S. Riggs, Washburn. Lantern. 10 min.
5. A Spectroscopic Study of an A. C. Arc with Auxiliary Heater. Blaine E Sites, Salina High School. Lantern. 10 min.
6. Notes on the Evaporation of Thin Metallic Films. David M. Gates, U. of Michigan. (By title).
7. Experimental Evidence Bearing on the Probable Importance of Initial Static as One of the Six Essential Factors in the Combinational Causes of Dust Storms. B. Ashton Keith, The Institute of Science, Kansas City. Lantern. 12 min.
8. The Thousand-cycle Audio Oscillator as an Effective, Low-cost Device in Code Instruction. H. A. Zinszer, F. H. K. S. C. 10 min.
9. Experimental Evidence for the new Neutrino. J. S. Allen, K. S. C. Lantern. 15 min.
10. Demonstration of a Chromatic Stroboscope. E. K. Chapin, K. S. C. 15 min.

PSYCHOLOGY

Chairman, H. E. Schrammel

FRIDAY, MARCH 27

9:00 a.m. to 10:25 a.m., Science Hall, Room 202

1. Subjective Estimates of Agencies that Affect Character. George N. Mendenhall, Sterling Col. 10 min.

2. Mutual Participation in Adjustment Techniques as a Factor in Problems Involving Present Human Relationships. Edwina A. Cowan, Child Guidance Clinic, Wichita. 15 min.
3. Further Studies of Learning Aptitude in Pilots—A: Prediction of Flying Aptitude. William Guy Matheny, F. H. K. S. C. 7 min.
4. Further Studies of Learning Aptitude in Pilots, B: Prediction of Ground School Aptitude. Winifred A. Baker, F. H. K. S. C. 7 min.
5. Securing Both Time-Limit and Work-Limit Scores on Tests of Mental Ability. J. C. Peterson, K. S. C. 10 min.

Afternoon Session, 1:00 p. m. to 3:30 p. m.

6. Recent Developments in Clinical Psychology. D. Rapaport, The Menninger Clinic, Topeka. 15 min.
7. Further Studies of the Use of the G. S. R. in Deceptive Detection. E. W. Geldreich, K. S. T. C., Emporia. 10 min.
8. The Thurstone Vocational Interest Schedule and Students' Actual Vocational Choices. Leslie Briggs, F. H. K. S. C. 10 min.
9. Current Phase of Personality Measurement. Robert T. McGrath, F. H. K. S. C. 10 min.
10. The Effects of College Entrance Delay on College Grades. H. C. Stuart, Garrison High School. 10 min.
11. Variations on Similar Learning Tests Involving Simple Verbal and Non-Verbal Material. Irvin T. Schultz, Friends U. 5 min.
12. Requirements for Master's Degrees in Eighty-One Prominent American Colleges. J. C. Peterson, K. S. C. (By title).
13. The Purpose, Origin, Plan of Procedure, and Values of the Nationwide Every Pupil Scholarship Tests. H. E. Schrammel, K. S. T. C., Emporia. (By title).
14. Local Results in Code Learning Compared with the Bryan-Harper Learning Curves. H. A. Zinszer, F. H. K. S. C. 10 min.

ZOOLOGY

Chairman, E. H. Herrick

FRIDAY, MARCH 27

9:00 a. m. to 10:25 a. m , Science Hall, Room 210

1. Notes on Some Animal Activity in the White Sands National Monument, New Mexico. R. E. Bugbee, F. H. K. S. K. Lantern. 10 min.
2. A Preliminary Report upon the Mollusca of Kingman County, Kansas. Dorothea Frazen and A. Byron Leonard, U. of K. Lantern. 10 min.
3. Litter Records of Some Mammals of Meade County, Kansas. George C. Rinker, U. of K. 5 min.
4. The Saw-whet Owl in Kansas. George C. Rinker, U. of K, 3 min.
5. Some Observations of the Food Coactions of Rabbits in Western Kansas During Periods of Stress. Andrew Riegel, F. H. K. S. C. Lantern. 10 min.
6. A Study of the Oligocene Leporidae in the Kansas University Museum of Vertebrate Paleontology. Morton Green, U. of K. 5 min.

7. Report on a Remarkable Concentration of Attention in a Bird. Ashton Keith, Inst. of Sciences, K. C., Mo. 3 min.

Afternoon Session, 1:00 p. m. to 3:30 p. m.

8. Propagation of the Spotted Channel Catfish (*Ictalurus lacustrus punctatus*) at the State Fish Hatchery, Pratt, Kansas. Leo Brown, Pratt, Kansas. 8 min.
9. Relationship of Barometric Pressures to Fishing Conditions. Elmo W. Huffman, Kansas Forestry Fish and Game Commission, Pratt, Kansas. 10 min.
10. Kansas Fish in the Kansas State College Museum at Manhattan. Dolf Jennings, K. S. C. 10 min.
11. Seasonal Activity in Squirrel Testes. E. H. Herrick, K. S. C. Lantern. 8 min.
12. The Influence of Certain Genetic Factors upon Eye Color in the Guinea Pig. Mary T. Harman and Annette Alsop Case, K. S. C. 10 min.
13. The Eleventh Annual Insect Population Survey of Kansas—1941. Roger C. Smith, K. S. C. 7 min.
14. Investigations into the Early Phases of the Life History of *Blatticola blattae,* a Nematode found in *Blatella germanica.* Wilfred B. Bozeman, Jr., U. of K.
15. A Histological Study of the Digestive System of the English Sparrow, *Passer domesticus domesticus.* L. J. Gier and Ottis Grounds, Jr. William Jewell Col., Liberty, Mo. 6 min. (By title).
16. Development and Reactions of Melanophores of Embryos and Larve of *Typhlogobius californiensis* Steindacher. B. R. Coonfield, Brooklyn Col., N. Y. (By title).

THE WEATHER—CROPS SEMINAR

Chairman, F. D. Farrell; Secretary, H. H. Laude

The annual meeting was held at Lawrence in December. No program was given during the meetings.

KANSAS CHAPTERS

AMERICAN ASSOCIATION of UNIVERSITY PROFESSORS

A. Bower Sageser, Kansas State College, Manhattan, presiding

SATURDAY, MARCH 28

Morning Session

10:00 a. m. to 12:00 noon, Science Hall, Room 202

1. The College Advisory Council at Kansas State College. Prof. C. M. Correll, K. S. C., Manhattan.
2. The Extension of Social Security to the Staffs of Institutions of Higher Learning. Prof. Domenico Gagliardo, U. of K.
3. Address—The Association and its Work. Prof. Frank E. E. Germann, U. of Colo.

Afternoon Session, 1:45 p.m.

Martha E. McGinnis, F. H. K. S. C., presiding.

1. What can the Local Chapter of AAUP do in the Present Crisis for its School and the Advancement of Education. Prof. Edgar Mendenhall and Prof. Harry Hall, K. S. T. C., Pittsburg.
2. Discussion of the above paper by members of the local chapters.

BIOLOGY TEACHERS

Chairman, Ralph L. Tweedy

SATURDAY, MARCH 28

10:00 a.m. to 12:00 noon, Science Hall, Room 309

1. The Objectives and Current Results of the Grass Program at the Fort Hays Experiment Station. L. E. Wenger. 20 min.
2. Photography as an Aid in Teaching Biology. Andrew Riegel, F. H. K. S. C. 15 min.
3. Color Pictures of Native Wild Life. Andrew Riegel, F. H. K. S. C. 15 min.
4. How I Teach High School Biology. Sherman B. Griswold, Newton High School. 15 min.

COLLEGE STUDENTS

Chairman, Dean E. O. Deere

SATURDAY, MARCH 28

10:00 a.m. to 12:00 noon, Science Hall, Room 113

Mimeographed copies of the program to be distributed at the meeting.

JOINT SESSION

MATHEMATICAL ASSOCIATION OF AMERICA

KANSAS SECTION

and

KANSAS ASSOCIATION OF TEACHERS OF MATHEMATICS

FRIDAY, MARCH 27

Evening Session

8:00 p.m. to 10:00 p.m., Science Hall, Room 209

C. F. Lewis, K. S. C., presiding

1. Is Mathematics An Exact Science? C. B. Read, U. of Wichita. 15 min.
2. Continued Fractions of Quaternions. Earl G. Swafford, F. H. K. S. C. 15 min.
3. Subject to be announced. G. B. Price, U. of K. 15 min.

"Get Acquainted Hour."

SATURDAY, MARCH 28

Morning Session

9:30 a. m., Science Hall, Room 209

C. F. Lewis, K. S. C., presiding

1. Mathematics in Business. Speaker to be announced.
2. Some Circles Related to a Triangle. G. W. Smith, U. of K.
3. Report of Committee on Placement Test. Dean Gilbert Ulmer, U. of K.

12:00 noon Luncheon and Business Meeting, Cody Commons.

Afternoon Sessions

Kansas Association of Teachers of Mathematics

2:00 p.m. Science Hall, Room 209. Kathleen O'Donnell, Salina, presiding.
Teaching Geometry to Develop Clear Thinking. Dean Gilbert Ulmer, U. of K.
Discussion.

Mathematical Association of America

2:00 p.m. Science Hall, Room 210. C. F. Lewis, K. S. C., presiding.
Report of Committee on Placement Test. J. O. Peterson, K. S. T. C., Emporia.
Discussion.
Business Meeting.

1
Presidential Address

FRANK C. GATES, Kansas State College, Manhattan, Kansas

PLANT SUCCESSION*

This brief discussion of succession may well begin with these two quotations: "Only one thing is constant and that is change," and a quotation from Walt Whitman: "Law is the unshakable order of the universe forever; and the law over all, and law of laws, is the law of successions."

Thus we may express the idea of succession. Something is, something was; something is not, something becomes.

Animal groups rise, decline and become extinct; as for instance the dinosaurs. The same is true for plant groups. Witness the Sigillarias, the Calamites and the Lepidodendrons. Mountains rise only to be worn away to foothills and plains. Nature is forever showing examples of such a rise and fall. Nothing remains constant. A new order is always arising and in due time giving place to a newer order.

Even in the affairs of man we see similar changes and successions. Civilizations rise and fall. Succession is often a bitter pill for those who want fixity upon arriving at a goal. But nature works on with an abundance of time at her disposal. Are we witnessing such a decline (succession) in civilization at the present time? Certainly when Japan introduced gangsterism in the Pacific in the early days of the century and repeatedly by word of mouth, in print, and by deed made it evident what she was going to do, we can scarcely look with pride upon our patronizing attitude and lack of preparedness. No. Theodore Roosevelt was right when he said: "Speak softly but carry a big stick."

But let us turn back from this brief digression and look into some successions in plant life.

The development of vegetation gives us many examples of succession and one of the simplest is the turning of a lake into dry land thru the various stages dominated by aquatic plants, marsh plants, bog sedge, shrubs and forest trees (Fig. 1.).

In the northern part of our country, the retreat of the glaciers left many depressions in the ground which filled with water, or great cakes of ice which in melting left kettle holes in the ground. The lakes which resulted became vegetated. The first underwater plants included certain kinds of algae and pondweeds. Next appeared plants whose leaves float on the surface of the water, as for example, waterlilies.

Soon after sedges appear in the vegetation along the shore. One of the sedge species is destined to be of great importance, for upon its invasion and growth depends the future course of development of the area. For a time

Transactions Kansas Academy of Science, Vol. 45, 1942.

*Presidential address delivered at Hays, Kansas, March 27, 1942. In this printed account some explanations, as well as most of the 60 pictures, have been omitted.

Contribution No. 436 from the Department of Botany and Plant Pathology, Kansas State College of Agriculture and Applied Science.

there may be other sedges as bulrushes (*Scirpus validus*), etc., rooted in the bottom and projecting above the water into the air. If bulrushes continue as the dominant vegetation, a swamp is the outcome.

To have a bog, on the other hand, the sedge known as *Carex lasiocarpa* must make its appearance and thrive. Its roots and rhizomes, which at first have been developing in the muddy, gravelly or sandy edge of the lake, do not go deeper into the substratum, but begin to grow out into the water. The underground parts are densely massed together, but the important and most interesting point is that they are massed together in the water above the actual bottom of the depression. Upon its growth depends the development of a mat which floats on the water and gradually covers over the lake with vegetation. Since the mat floats, the depth of the water is not important.

The actual filling up of the depression is of course from materials which are continually dropping off the bottom of the mat. The deeper the lake, the longer the time to fill the lake, other things being equal. This mat, which may be 2 to 2.5 feet in thickness, accommodates itself to changes in the water level, which in most northern lakes fluctuates with the seasons and the years. In the two lakes where measurements have been taken, one a Minnesota lake measured by Dr. and Mrs. Buell for a few years (Ecology 22:317-321, 1941) and the other a bog lake in northern Michigan which I (Science 91:449-450, 1940) have been measuring for the past 20 years, the extent of change in level is almost 2.5 feet.

Beneath this mat there is almost certain to be some open water above the accumulation of material on the bottom. As filling goes on, however, the material accumulates up to the bottom of the mat. This organic material increases in density from year to year and the mat comes to rest upon it. While this process is taking place, other plants are finding the conditions on the mat suitable for their growth. The commonest of these plants in northern Michigan is *Chamaedaphne calyculata,* an ericaceous shrub, making bushes up to about a meter in height. The roots of Chamaedaphne tangle with the mat of *Carex lasiocarpa* and the stems of Chamaedaphne weighed down by the snow add to the tuffness of the mat.

The *Carex lasiocarpa* is gradually killed by the shade of the developing Chamaedaphne bushes. Into the well-developed Chamaedaphne association come seeds of shrubs which grow taller than Chamaedaphne. Chamaedaphne first responds by developing shade leaves, but sooner or later Chamaedaphne is shaded out and so the high bog shrub association comes to occupy the ground. By this time the mat is quite certain to be firmly grounded, altho not necessarily with firm hard peat beneath it.

Trees now enter into the succession. Three kinds are prominent in northern Michigan, *Larix laricina* (tamarack), *Picea mariana* (bog spruce) and *Thuja occidentalis* (white cedar) usually succeeding each other in that order. No other trees follow the Thuja association as long as the area is a bog. Thus we have seen an open lake transformed into a tree-covered area by a series of successions.

Many such areas in the north central states have become the fine farmlands of today. This statement is especially true of the earlier glaciated areas, but in time it will also be true of areas farther north which were covered by the latest glaciation.

FIGURE 1. A bog lake near Ann Arbor, Michigan, showing open water and zones of plant associations, from right to left, water lily, *Carex lasiocarpa*, Chamaedaphne, high bog shrub and trees. June 1911.

FIGURE 2. A former active stream in the Waukegan flats, Illinois, made sluggish with a sandbar across the mouth. The stream channel completely choked with vegetation. August 1910.

Sandbars frequently separate ponds or beachpools from the main bodies of water, or they may sufficiently check the flow of water in a stream to permit vegetation to cover it (Fig. 2.). Such a series of plant associations makes the phenomenon of succession easy to observe.

A river flows in meanders, perhaps with climax forest on either bank. During a flood a new channel may be cut thru the forest. Ecologically, this is a setback from climax to pioneer vegetation. A new series of associations immediately goes to work to rebuild what was torn down.

Sand dunes illustrate succession from the efemeral dunelets of *Euphorbia polygonifolia* along the shore of Lake Michigan thru stages where the outstanding sandbinding grass, Ammophila spp., builds up dunes many feet high. These dunes may become treecapped, as has Sleeping Bear dune near Glen Haven, Michigan—only to be destroyed when man, by breaking the vegetative cover, allows the sand to be blown away (Fig. 3).

Buildings, which had been located on certain sandy areas at Douglas Lake, Michigan, for varying lengths of time (3 to 18 years) were all moved away in 1929. Observations made 11 years later showed that vegetation returned quickest and most completely to those areas which had been covered by buildings for the shortest period.

To those of us who knew the prairie previous to the drouth of the past decade and respected the stalwart prairie dominants as invincible, the report of degenerations which Albertson and Weaver (Ecol. Monog. 12:23-51, 1942, etc.) have brot us is amazing. As a result of this great drouth, which has established *Sporobolus cryptandrus, Agropyron smithii,* and *Bouteloua curtipendula* as species of major importance, we have a splendid proof of the dynamic nature of vegetation. Even a most stable of vegetational climaxes is adapting itself to current climatic variation by undergoing profound changes.

Mountain grasslands in the Philippines remain so only because of fires set by the Filipinos which prevent the growth of normal dipterocarp or mossy forests climatically normal to the region. However, the Filipino farmer uses the principle of succession to good advantage in restoring grassland to cultivation. Instead of plowing up the grassland which he cannot well do with the tools at his disposal and which, if he did, would regenerate faster than he wants to cultivate, he plants seedlings of ipil-ipil (*Leucaena glauca*) a few feet apart and keeps the grass cut around them until these small leguminous trees become as high as the grass. The spreading crowns of Leucaena shade the grass completely and within 15 to 18 months this grass is completely eliminated. The farmer thereupon cuts the trees and gets firewood of suitable size for his needs. The stumps are easily pulled if desired and the necessary cultivation and care of the crop maintained until the tough cogon grass (*Saccharum spontaneum*) reinvades (Figs. 4 and 5).

Other illustrations of trees succeeding grasslands are pines following grass in Benguet Province and *Casuarina equisetifolia* displacing grassland in Zambales a little north of Bataan, but even here in Kansas, pines can spread out from planted groves if there is no fire (Ecol. 7:96-98, 1926).

The development of a cottonwood forest near Manhattan, Kansas, has been observed, as well as a cycle on a flat out of water only at times of low water. The latter cycle included a stage of competition between weeds, willows and

cottonwoods, with the cottonwoods beginning to win when high waters, too long remaining, killed all and the cycle started over (Fig. 6).

Destructive effects of volcanic activity are illustrated by Teal volcano in the Philippines, where the eruption of 1911 killed all the vegetation at least down to the ground. All the trees were killed on the slopes directly exposed to the volcano and revegetation was initiated by grass (*Saccharum spontaneum*). On the least exposed slopes the trees which had not been killed by the sulfuric acid in the eruption revegetated the devastated slopes with trees without a grass stage (Philippine Journ. Sci., 9, C:391-434, 1914).

Within the present century a remarkable example of succession of great importance has appeared. A hybrid grass, *Spartina townsendii,* appeared in nature in northwest Europe. This hybrid is able to colonize the mud flats along the coasts of England, France, and nearby countries and in a surprisingly short time turn the mud flats into firm meadows (Figs. 7-9).

The great forests of Douglas fir (*Pseudotsuga taxifolia*) in western United States do not represent the climax vegetation. In the absence of fires, even at intervals of more than 200 years, the Douglas fir will be succeeded by Engelmann spruce or western hemlock, neither of which is so valuable commercially.

The recorded changes in the crown forests of Scandinavia are an excellent example of succession but in the reverse direction of what we are used to in this half of the world. Former great forests held by the crown for hunting and not subject to exploitation have, nevertheless, within the past 10 or 11 centuries of recorded time gradually changed from forests (taiga) to shrubs and nearly to tundra.

Investigation in northern Siberia illustrates a similar order of succession from trees to shrubs to tundra—whereas on the American continent tree associations are working northward into the tundra. A northward extension of many forms of life as plants, insects and birds in America has attracted attention during the past century.

The basic principle of change is well illustrated from the field of plant pathology. Let us take as an example of economic importance, the rust fungi. It is known that the common stem rust of wheat, *Puccinia graminis tritici,* has several races and that different kinds of wheat are differently affected by some of these different races. One may think his work is done when, by proper selection and plant breeding, he secures a wheat which is only slightly affected by the races of stem rust in the particular region. But such is too often not the case, for within a few years either the wheat modifies, or the fungus changes, and the superiority of the wheat is lost. Experimental work and plant breeding have to do their best to keep at least one jump ahead of nature.

HOW SUCCESSION IS ACCOMPLISHED

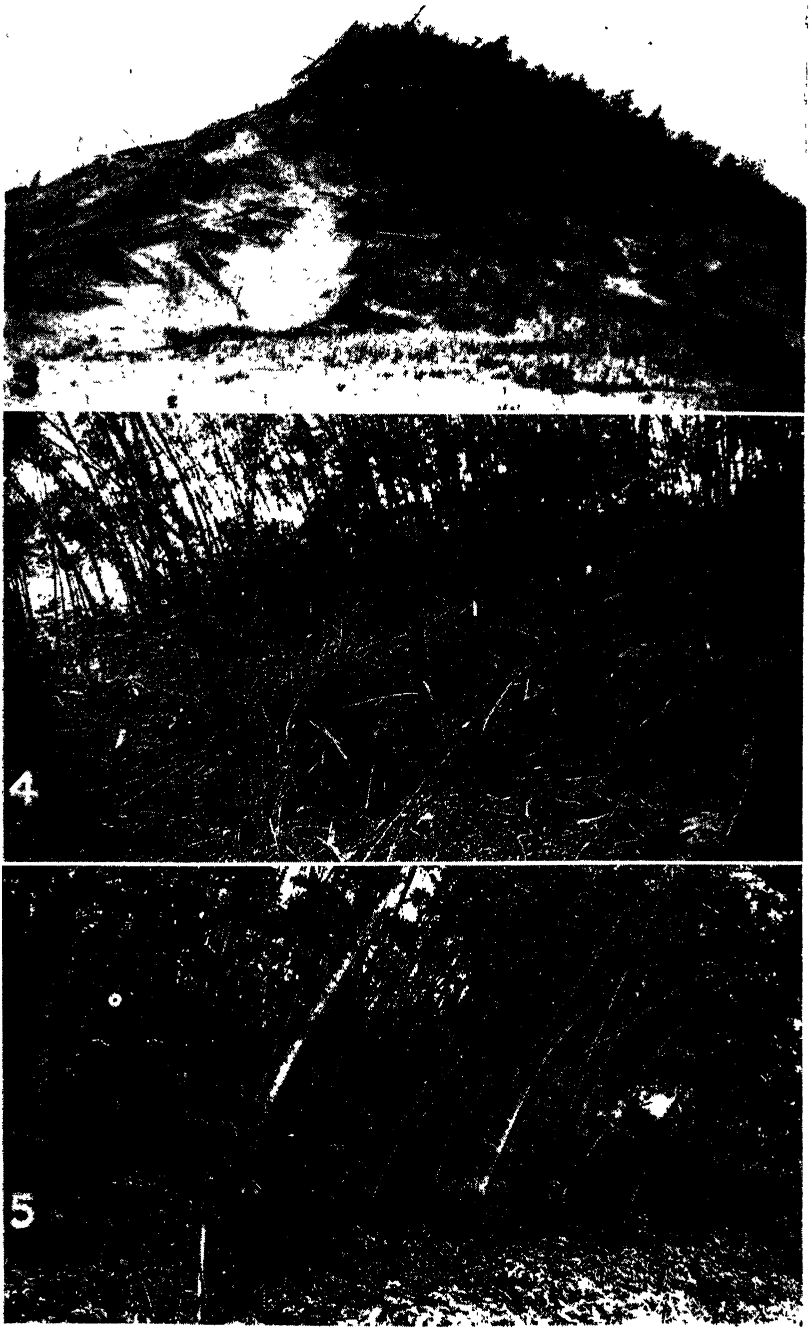
When a given plant association occupies a given bit of ground, the first indication of a possible succession is the appearance of seedlings of the dominant plants of the association which will follow—an infiltration of representatives of the new order. Should these seedlings find conditions so favorable that they can grow to maturity and acquire dominance, then a succession is completed. Some of the individual plants belonging to the earlier association may remain as relics in the association succeeding. When, under the climatic conditions obtaining, no association can replace the one existing, the association present is called the climax association. Such need not last

EXPLANATION OF FIGURES

FIGURE 3. Sleeping Bear dune, Michigan, formerly completely covered with forest. A wide path on the west (left hand), made several years previously, gave the wind a chance to undercut the trees, resulting in the destruction of all the trees on the west side. Height of dune about 90 feet. July 1941.

FIGURE 4. Destruction of the cogon grassland (*Saccharum spontaneum*) well under way thru the growth of the planted *Leucaena glauca*. Near Los Banos, P. I. March 1913.

FIGURE 5. Destruction of the cogon grassland completed. Near Los Banos, P. I. February 1914.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time—witness the fact that eastern Kansas was covered with a spruce forest in days when western Kansas was still under the ocean.

The identification of change or of succession with progress is often made but it does not seem to me to be a necessary relationship. Change in itself bears no relationship as to whether the outcome is or is not considered desirable by human beings. Some changes are induced by man, such as clearing of original vegetation for cultivation, but this condition will not maintain itself. It requires repeated attention and unremitting toil, or the land will revert to the original vegetation—sometimes rather quickly.

Many times man thinks that he is making progress in some of the changes which he engineers. However, in plowing up so much of the high plains after the first World War, he released the topsoil to blowing in the very dry years which followed and this drove him off the land.

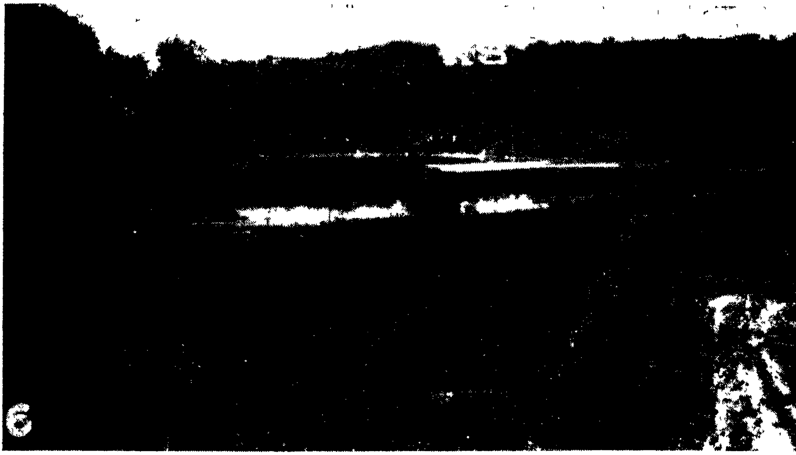
The problem is of course for man to make his changes within the limitations of natural factors which must govern all living things, including man, and if possible within the limits of natural successions. Man does not like to thus limit himself. But if man will not fit himself into nature and her laws, nature takes a terrible toll sooner or later. It may be worth it for each new generation to make its own mistakes, commit its own follies, and to ignore what has gone before but to do so is hardly scientific and certainly far from efficient.

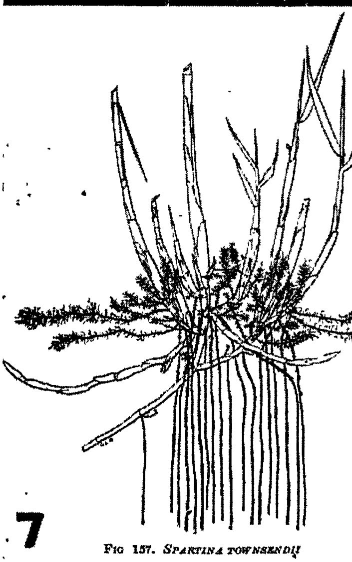
Man has done many things to vegetation but he has not done too well when he has ignored the trends of the great successions. Man has not been able to turn grasslands into permanent forests. He has done a little better, perhaps, when he has set vegetation back, to start anew its course, such as turning forests or grassland into cultivated crops or pastures. But what happens when he ceases to maintain either? They return to their former type of vegetation, frequently with amazing rapidity.

Man has planned many things with plants to his seeming advantage, but he usually forgets to take into account all the factors. So, ignoring consequences, he upsets the balance of nature in many ways. With patience and perseverance and much hard labor, man may hold nature at bay, or even improve upon her, as he says, but let him relax these efforts or go too far in disturbing the balance of nature and retribution is sudden and often disastrous.

Succession is like a river. It goes on and on towards its goal. Man may thwart it by dams or by removing the water but he can never do more than check it temporarily in its path. If he relaxes his vigilance, what was gained is lost. Better for man to become thoroughly conversant with the great natural laws of succession.

In closing I quote again: "Only one thing is constant and that is change," and "The moving finger writes, and having writ moves on."





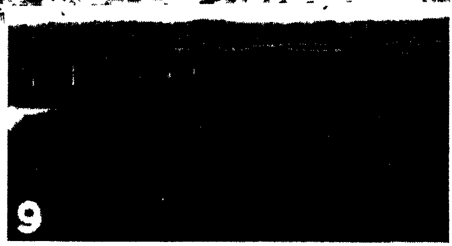


FIGURE 6. Sand Lake near Manhattan, Kansas. Once a cornfield, made into a lake by the use of sandsucking machinery. Where permitted, the surrounding vegetation has reached the tree stage. Note particularly the spit jutting out into the lake. On this spit three cycles of weeds-shrubs-small trees have occurred within the past 18 years, only to be set completely back through floods. May 1932.

FIGURE 7. *Spartina townsendii,* showing bases of stout ascending aerial shoots, horizontal rhizomes and feeding roots, and deeply penetrating vertical anchoring roots. From F. W. Oliver.

FIGURES 8 and 9. Views along the south coast of England near Dorset, showing colonization of the soft mud flats by *Spartina townsendii.* Fig. 8, by R. V. Sherring in June, 1911, and Fig. 9 in essentially the same spot 13 years later. June 1924. F. W. Oliver. (Figs. 7-9 appeared in Tansley, A. G. "The British Isles and their Vegetation," 1939.)

2

The Heat Resistance of Streptococcus Thermophilus Grown in Mixed Culture With Caseolytic Bacteria[1]

H. J. PEPPLER, Kansas State College, Manhattan, Kansas

The increased heat resistance of *Streptococcus thermophilus* and *Lactobacillus helveticus* grown in mixed culture with *Candida krusei*, a film-forming yeast, has been observed by Peppler and Frazier (1). The beneficial effect of the film yeast on the bacteria was greatest near the surface of the medium where the yeast grew abundantly. The influence of the yeast was attributable to the combined effect of reduced oxygen tension, reduced acidity, and accessory substances formed during the association with the lactic acid bacteria. It was suggested that other microorganism grown with acid-forming bacteria may increase the activity of the lactic acid bacteria after severe temperature exposures.

The present study is a preliminary report of data showing the effect of different caseolytic bacteria on the heat resistance of lactic acid organisms grown in mixed culture in milk.

The addition of peptones and malt extract to a reconstituted skimmilk medium is known to increase the rate of acid development and heat resistance of *Lactobacillus helveticus* (2) and *Streptococcus thermophilus* (3). It is probable that certain proteolytic bacteria grown in whey can produce protein derivatives more available to pure cultures of the acid-forming bacteria than the proteins of milk. Therefore the enrichment of ordinary skimmilk media with small amounts of heat-killed whey cultures of caseolytic bacteria should increase the heat resistance of *S. thermophilus* and *L. helveticus*. The following experiments indicate the extent to which such enrichments of milk are a useful method of preparing heat resistant lactic acid bacteria.

EXPERIMENTAL

Methods described by Peppler and Frazier (2) were modified to determine the activity of *Streptococcus thermophilus* at 48° C. after a heat treatment at 65° C. for 30 minutes.

Whey was prepared by adding 0.02 per cent rennet extract to pasteurized skimmilk at 32° C. The coagulum was cut and heated to 60° C. and held for 10 minutes. After filtration thru cotton, 100 ml. and 10 ml. quantities were sterilized in an autoclave. Cultures of *Streptococcus liquefaciens, Pseudomonas aeruginosa, Achromobacter lipolyticum*, and *Lactobacillus bulgaricus* associated with *Candida krusei* were grown in 10 ml. of whey at 36° C. After numerous culture generations, transfers were made to 100 ml. of whey; these cultures were usually incubated for 24 hours at 36° C. and then stored five days at 28° C. The cultures were steamed 10 minutes before adding 5 to 8 per cent of them to 100 ml. of fresh 10 per cent reconstituted skimmilk.[2]. A one per cent inoculum of *S. thermophilus* or *L. helveticus* was prepared from

[1]Contribution No. 212, Department of Bacteriology. Published with the permission of the director of the Kansas Agricultural Experiment Station.

[2]Prepared from the same lot of spray-dried powder.

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24-hour stock cultures (36° C.) carried in reconstituted skimmilk. After incubation at 36° C. for 16 hours, a sample was removed, a uniform suspension was made in a balanced salt solution (4), and 0.6 ml. added to 240 ml. of the sterile skimmilk medium contained in an Erlenmeyer flask (500 ml.). The suspension of organisms in the flask received the heat treatment; it is referred to as the heat-treated subculture. The culture from which the suspension for the heat treatment was made is designated as the inoculating culture. Heat-treated subcultures were incubated in a constant temperature bath near the maximum growth temperature of *S. thermophilus* and *L. helveticus.* The rate of acid production was determined with a glass electrode. Plates were poured with samples removed from the flasks before and after the heat treatment. Carrot agar[3] was used to determine the number of thermoduric lactic acid bacteria. Nutrient agar and new standard milk agar were employed to count other organisms when mixed cultures of *S. thermophilus* and caseolytic bacteria were studied. Colonies of *S. thermophilus* developed poorly or were absent on media other than carrot agar.

Small additions of certain whey preparations to the inoculating cultures appeared to be more beneficial to *S. thermophilus* than *L. helveticus.* The data shown in Table I indicate that whey cultures of *S. liquefaciens* and *A. lipolyticum* contain substances which increased significantly the heat resistance of *S. thermophilus,* as measured by the decrease in pH following the severe heat treatment. The growth products of *P. aeruginosa,* however, increased the heat resistance of both *S thermophilus* and *L. helveticus.* In most cases the stimulatory effect of specific whey cultures was also revealed by the low pH of the inoculating cultures. The beneficial effect of the culture of *L. bulgaricus* used may be attributable to the growth of *Candida krusei* associated with it.

It was desirable to compare the results obtained with whey culture preparations with the effect of different nitrogen sources tested under similar experimental conditions. Inoculating cultures of *S. thermophilus* were prepared with the following additions: 0.3 per cent asparagine, 0.5 per cent ammonium phosphate ($NH_4H_2PO_4$), and 0.1 per cent of Bacto peptone, Bacto-tryptone, Bacto neopeptone, and Bacto proteose peptone. The activity of the heat-treated subcultures, shown by the data of Table II, was greatest when *S. thermophilus* was grown in skimmilk enriched with various peptones.

TABLE I. Influence of different whey culture additions to skimmilk on the heat resistance of *Streptococcus thermophilus* and *Lactobacillus helveticus.*

Inoculating Culture		Heat-treated subculture		
Whey culture added	pH	Plate count before heating	Plate count after heating	Decrease in pH in six hours[1]
		thousands /ml.	thousands /ml.	
			S. thermophilus	
Streptococcus liquefaciens	4 25	585	79	.96
Lactobacillus bulgaricus	4.40	665	185	.60
Achromobacter lipolyticum	4.15	775	98	.72
Pseudomonas aeruginosa	4.29	775	219	.80
None	4.49	513	183	.42
			L. helveticus	
S. liquefaciens	4.20	1,500	1,120	.19
A. lipolyticum	4.00	1,940	1,480	.22
P. aeruginosa	4.02	1,980	1,590	.99
None	4.27	1,600	1,230	.17

[1]Incubation at 48° C. (*S. thermophilus*) or 44° C. (*L. helveticus*) after surviving 30 minutes at 65° C. or 64° C., respectively, in milk.

[3]Carrot agar: Bacto neopeptone 10 g., Bacto peptonized milk 10 g., glucose 3 g., carrot extract (1 lb. ground carrots extracted in one liter water at 70–80° C. for one hour) 400 ml., Bacto agar 18 g., dist. water to one liter. Adjust to pH 6.8 before sterilization.

It is to be noted that the cultures grown in peptone-milk were equivalent in heat resistance to those cultures which received the whey preparation enrichments noted above. The heat resistance gained by growth in Neopeptone-milk was lost, however, with the first transfer to the stock skimmilk medium (Table II). The concentration of ammonium phosphate and asparagine employed failed to increase the heat resistance of *S. thermophilus.*

These data suggest that the favorable effect of caseolytic bacteria is related to the content of soluble nitrogenous compounds formed in whey; their addition to skimmilk provides a nitrogen source more readily available than casein or albumin. The high degree of caseolytic activity of *S. liquefaciens* has been reported by Orla-Jensen (5).

If the proteolytic organisms and *S. thermophilus* are compatible in mixed culture, the concurrent action of caseolytic organisms should stimulate the growth of *S. thermophilus.* Therefore, inoculating cultures received equal amounts of the different 24-hour cultures grown in skimmilk at 36° C. An inoculum of one per cent was satisfactory. Samples were heat-treated in the usual manner, and their activity at 48° C. after surviving 30 minutes at 65° C. is shown by the data of Table III. The influence of *S. liquefaciens* and *S. zymogenes* upon the heat resistance of *S. thermophilus* was greater than that exhibited by the other bacteria studies. Association with *P. aeruginosa* was markedly beneficial to *S. thermophilus,* while the results with *A. lipolyticum* and *Proteus ammoniae* were inconclusive. Experiments now in progress indicate that the effectiveness of these two organisms is a function of the amount of inoculum. When the inocula of *S. thermophilus* and *A. lipolyticum* or *P. ammoniae* were made in the ratio of 1:3, the heat resistance of the acid-forming organism increased sharply.

TABLE II. Influence of various nitrogen sources on the heat resistance of *Streptococcus thermophilus* grown in milk.

Inoculating Culture		Heat-treated subculture		
Nitrogen source added	pH	Plate count before heating	Plate count after heating	Decrease in pH in six hours[1]
		thousands /ml.	thousands /ml.	
None	4.48	465	188	.28
Ammonium phosphate	4.43	450	173	.25
Asparagine	4.48	450	236	.33
Peptone	4.20	730	350	.80
Proteose peptone	4.03	840	457	.82
Neopeptone (a)[2]	4.03	1,050	339	.82
(b)[3]	4.40	425	129	.31
Tryptone	4.05	745	157	.75

[1]During incubation at 48° C. after surviving 30 minutes at 65° C. in milk.
[2]Added to inoculating culture
[3]Added to culture from which inoculating culture was made.

TABLE III. The heat resistance of *Streptococcus thermophilus* (C_3 and Mc) after growth in skimmilk with different bacteria.

Inoculating Culture		Heat-treated subculture		
Organisms	pH	Plate count before heating[1]	Plate count after heating	Drop in pH in six hours[2]
		thousands /ml.	thousands /ml.	
C_3 alone	4.40	530	152	.13
C_3 + P. aeruginosa	4.27	720	273	.59
C_3 + S. liquefaciens	4.21	985	421	.82
C_3 + A. lipolyticum	4.27	615	424	.38
C_3 + Proteus ammoniae	4 49	470	141	.25
Mc alone	4.55	575	10	.22
Mc + S. zymogenes	4.26	1,230	131	.66
Mc + S. liquefaciens	4.26	1,105	168	.82
Mc + P. aeruginosa	4.49	1,005	152	.53

[1]Count of *Streptococcus thermophilus.*
[2]During incubation at 48° C. after surviving 30 minutes at 65° C. in milk.

DISCUSSION

The preparation of heat resistant cultures of lactic acid bacteria is a practical problem in certain industries, especially in the manufacture of Swiss cheese. Many factors, such as time and temperature of incubation and the character of the culture medium, influence the heat resistance of the starter organisms. The properties of the culture medium are frequently difficult to control. According to the preliminary results reported here, the association of certain lactic acid bacteria with proteolytic types provides a convenient and inexpensive method of ensuring a satisfactory medium for the preparation of heat resistant cultures of acid-forming bacteria. The extent to which mixed cultures can be used may depend upon the heat resistance of the caseolytic associate. Observations in the present study indicated that their heat resistance is low. Under conditions precluding the use of mixed cultures, however, the stimulatory substances can be supplied by heat-killed whey cultures of the proteolytic organisms.

The increased heat resistance of the lactic acid organisms is probably related to the availability of nitrogen in the culture medium. Incomplete results, not reported here, suggest that accessory substances such as calcium pantothenate, l-ascorbic acid, riboflavin, thiamin, and nicotinic acid are not concerned in the loss or gain in heat resistance.

SUMMARY

Heat-killed whey cultures of *S.liquefaciens, A.lipolyticum,* and *P.aeruginosa* stimulated the rate of acid production and increased the heat resistance of *S. thermophilus* and *L. helveticus.* The degree of stimulation and increase in resistance to heat was equivalent to that shown by additions of various peptones.

After growth in mixed culture with *S liquefaciens* or *S. zymogenes,* the heat resistance of *S. thermophilus* was increased markedly. Moderate increases in heat resistance were observed after association with *P. aeruginosa* or *A. lipolyticum.*

LITERATURE CITED

1. PEPPLER, H. J., and W. C. FRAZIER. Influence of a film yeast, *Candida krusei,* on the heat resistance of certain lactic acid bacteria grown in symbiosis with it. J. Bact. 43: 181-191. 1942.
2. PEPPLER, H. J., and W. C. FRAZIER. Factors affecting the activity and heat resistance of Swiss cheese starter cultures. IV. Effect of variations in time and temperature of incubation and of storage on heat resistance of cultures. J. Dairy Sci. 24: 611-623. 1941.
3. ELLIKER, P. R., and W. C. FRAZIER. Factors affecting activity and heat resistance of Swiss cheese starter cultures. II. Influence of culture medium. J. Dairy Sci. 22: 821-830. 1939.
4. ALLISON, F. E., and S. R. HOOVER. An accessory factor for legume nodule bacteria. J. Bact. 24: 561-81. 1934.
5. ORLA-JENSEN, S. The ripening process of hard cheese. Rpt. Proc. 3rd Int. Cong. Microb. pp. 713-715. 1939.

3
Equine Sporotrichosis[1]

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The incidence of sporotrichosis in horses and mules in the United States was first definitely established by Page, Frothingham and Paige (1), who isolated a sporotrichum from the ulcerative lesions of horses and mules which Pearson (2) thought to be cases of epizootic lymphangitis. The detailed studies of Page and associates (1) indicated that the infectious agent closely resembled the sporotricha isolated from multiple abscesses in humans by Schenck (3), Hektoen and Perkins (4), Trimble and Shaw (5), and de Beurmann and Gougerot (6,7). Numerous studies (8,9,10) refer to this organism as *Sporotrichum schencki.*

The transmission of sporotrichosis from horses to humans was established by Hyde and Davis (11) and confirmed by Sutton (12) and Davis (13). The Hyde-Davis strain was used by Page and associates to inoculate a horse; the typical lymphangitis was observed (cited by de Beurmann and Gougerot (7). Meyer (14) concluded that human infections from equine sources of sporotrichosis are rare. Benham and Kesten (15) have shown that *S. schencki,* the usual cause of human sporotrichosis in the United States, produced a typical soft rot of the buds of carnation upon artificial inoculation. After plant passage the sporotrichum was still infective for rats and monkeys. One case of lymphangitis in a jack was observed by Frank and Kimball (16). The infectious agent was isolated from one of the several nodules; its identity as a colorless *Sporotrichum* sp. has been confirmed by Dr. Charles Thom. The clinical report of this case of sporotrichosis was released by Wendt (17).

With the appearance of numerous cases of sporotrichosis in solipeds during the past two years, it seemed desirable to review the significant characteristics of the mycotic infection and its causative agent in order that new cases can be recognized readily and the infectious agent identified quickly.

Roberts (18) reported the occurrence of several cases of epizootic lymphangitis in horses and mules of the Dominican Republic. Some of the lesions closely resemble those of sporotrichosis; however, the infectious agent was not described, precluding further comparisons.

Six cases of lymphangitis in equine were observed by the authors during the year of 1941. Identical cultures of *Sporotrichum* sp. were readily isolated from all cases; pure cultures of the infectious organism were obtained upon initial isolation from five of the six cases, all of which were sporadic in nature.

The disease is characterized by a suppurative inflammation of the superficial lymph glands. The lymphatics of the cervical and pectoral regions were most frequently involved, becoming swollen, greatly thickened, and very painful. The typical infection manifests itself as a chain of boil-like nodular lesions,

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as shown in Figure 1. In the latter stages these lesions tend to ulcerate and heal very slowly (Figure 2). Upon rupture or incision of the nodules, a very thick creamy, yellow-white pus is discharged. The sporotrichum was demonstrated in the pus and was readily isolated by streaking on Sabouraud's agar[3] and by inoculation of acidified liquid media. On subcutaneous injection of a pure culture into the axillary space of a horse, a typical nodule and swollen lymphatics were produced in four weeks.

The course of the disease may vary from three to eight weeks or more. All cases responded to treatment with iodine.

A detailed study of the cultural, morphological and biochemical characteristics of the pure cultures was made and the results compared with the culture isolated by Frank and Kimball (16).

Direct smears of pus stained by Gram's procedure revealed gram variable ovoid, yeast-like cells, 2μx 3-5μ. It is believed that these cells are blastospores. No hyphae or conidia-like structures were observed.

Upon initial isolation from pus the organisms grew in acid nutrient broth, or glucose broth, as a white fluffy, entire, entangled mass of hyphae, resembling a puffball, at the bottom of the medium; the remaining medium was clear (Figure 3). After several successive culture generations in liquid media, the organism developed a thick surface pellicle and numerous small, isolated nodular colonies in the medium along the wall of the tube. All growth in liquid media was white.

Luxuriant growth appeared on Sabouraud's agar, potato glucose agar, and carrot agar[4] within six to ten days at 28 to 36° C. Bacto cornmeal agar and Bacto wort agar were also excellent culture media for abundant and rapid development of the sporotrichum. On all media the colonies first appeared as a thin white adherent growth with rayed fringes penetrating the medium. After 5 to 7 days at 28° C. the center of enlarged colonies exihibited wrinkled, volcanic crests, resembling the conformation of the cerebellum. The center of the mycelium darkened rapidly as a black pigment formed in the mature conidia. Figure 4 illustrates the typical appearance of a ten-day culture of the sporotrichum on Sabouraud's agar.

The structure of the mycelium was readily determined by suspending the growth from artificial media in several drops of a five percent solution of potassium hydroxide. For careful microscopic study of developing colonies, Benham's method of preparing slide cultures, modified by Wickerham and Rettger (19), was found to be very desirable, especially for photomicrographs of morphological changes. Clean slides stored in acid alcohol were removed, the alcohol burned off, the slides immersed in melted cornmeal agar (held at 45° C.) and then placed in sterile Petri dishes. The congealed medium was inoculated lightly across the longitudinal center. A sterile cover glass was centered across the line of inoculation. The incubation of slide cultures in a moist atmosphere was achieved by supporting the slides on match sticks and adding a few drops of sterile water to the bottom of each Petri dish.

[3]Sabouraud's agar (Kimball's modification): glucose (tech.), maltose (tech.), and Bacto agar-20 g. of each, Bacto proteose-peptone 10 g., distilled water to one liter. When autoclaved at 15 lbs. pressure for 30 minutes the pH is near 5.5.

[4]Carrot agar: Bacto neopeptone 10 g., Bacto peptonized milk 10 g., carrot extract (1 lb. ground carrots extracted in one liter water at 70-80° C. for one hour) 400 ml., glucose 3 g., Bacto agar 18 g., distilled water 600 ml.

EXPLANATION OF PLATE

Fig. 1.—The character of sporotrichal lesions following the lymphatics of the cervical region.

Fig. 2.—A single nodular lesion in the late stages of sporotrichosis.

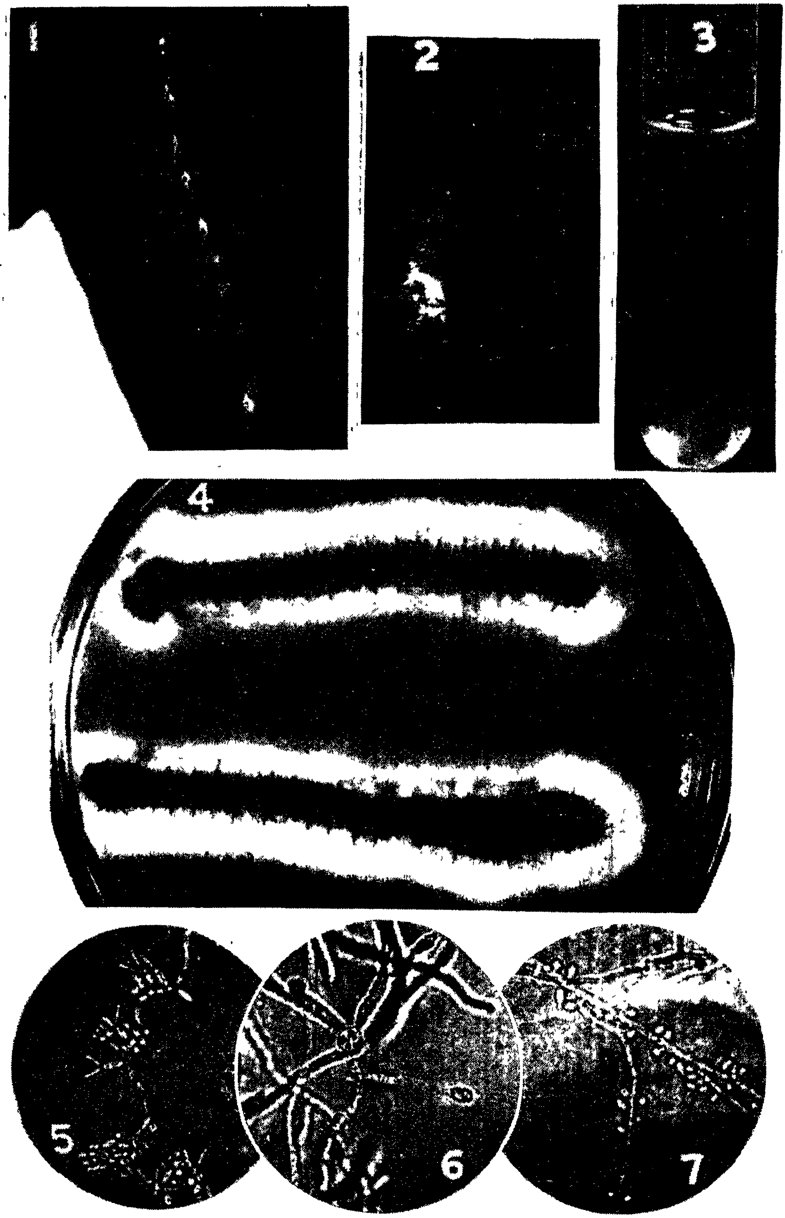
Fig. 3.—Appearance of growth of the sporotrichum on initial isolation in acidified glucose broth after ten days at 28° C.

Fig. 4.—Appearance of mycelium on Sabouraud's agar after ten days at 28° C.

Fig. 5.—Blastospores: slide culture, cornmeal agar, 7 days at 28° C; 550x.

Fig. 6.—Chlamydospores: same slide as figure 5; 550x.

Fig. 7.—Conidia; same slide as figure 5; 550x.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The components of the mycelium vary according to the position of growth along the line of inoculation from the edge of the superimposed cover glass. Below the center of the cover glass, where the lowest oxygen tension prevails, the hyphae were less abundant, the septa appeared at longer intervals and the development of blastospores was greatest (Figure 5); no spores were observed in this area. Approximately midway between the center and the edge of the cover glass, an area still less aerobic than that at the edge of the cover glass, the hyphae developed a preponderance of chlamydospores (Figure 6). Spherical chlamydospores, usually at the ends of hyphae or brastospores, were more abundant than the intercalary type. The presence of fat globules in the mature hyphae and chlamydospores was revealed by the preparations of growth from liquid media immersed in Sudan black B solution, according to the procedure of Hartman (20). In the most aerobic regions of the slide culture spherical conidia appeared in great abundance. Conidia developed singly at the sides of hyphae on the ends of very short sterigmata (Figure 7). Aggregates or clusters of conidia frequently appeared at the ends of mature hyphae.

A lactic acid fermentation occurred in 14 days at 28° C. in nutrient broth and meat infusion containing glucose, glycerol, and maltose. No gas was formed. Carbon sources not utilized by the sporotrichum include arabinose, xylose, mannose, galactose, fructose, sucrose, lactose, rhamnose, trehalose, mannitol, sorbitol, inulin, inositol, erythritol, and propylene glycol. Starch was hydrolysed in seven days. There was no action on gelatin in 14 days. In litmus milk a pellicle formed, but no color change or peptonization occurred. No indol was formed in Bacto tryptone broth.

DISCUSSION

The recognition of sporotrichosis, whether in man or domesticated animals, is facilitated by recovering the etiologic agent, *Sporotrichum* sp., from the pus. Acid media such as Sabouraud's agar, wort agar, potato-glucose agar, and acidified nutrient broth were found to be well suited to growth of sporotricha. Since sporotricha are sensitive to iodine, the identification of the infectious agent is significant in the treatment of sporotrichosis.

The classification of the genus *Sporotrichum* is too incomplete to ascertain the species. Dodge (21) divided the sporotricha into two groups: (A) eight species forming white to pink colonies on all media, and (B) two species developing brown to black colonies on most media. According to this classification the culture isolated by Frank and Kimball is a member of group A, but the organism isolated from the six cases observed in the present study is a species of group B. In the colored group Dodge recognizes two species: *S. schencki* and *S. jeanselmei*. The biochemical properties of the *Sporotrichum* sp. isolated by us do not agree with those of the colored species described by Dodge (21). It is possible that our strain may be a variant of either *S. schencki* or *S. jeanselmei*.

The seven cases of sporotrichosis reported in Kansas in 1941 are the first instances where the disease has been recognized and recorded in the literature of this state. Human cases have been observed infrequently in Kansas (5, 22).

A survey of sporotrichosis in humans prepared by Foerster (23) reveals that 130 of the 148 recorded American cases (1926) appeared in the Mississippi River basin. A preference for certain types of vegetation has been

suggested for the strikingly limited distribution of the sporotrichum infective to man. The Japanese barberry has been suspected of harboring the fungus, but no reports of isolations of sporotricha have appeared in the literature. In France strains have been isolated infrequently from beech bark, dried oat grains, wheat husks, and some insects (7). However no normal habitat has been found.

In the equine cases of Kansas the sources of infection have not been determined. It is believed that infection occurs after injury, such as thorn punctures or skin abrasions since subcutaneous inoculation of a pure culture produced the characteristic nodulation and swollen lymphatics observed in clinical cases.

Serological studies similar to those reported by Moore and Davis (24) have not been completed.

SUMMARY

A lymphangitis found to be sporotrichosis was observed in six horses. All animals recovered from the disease after intravenous and external treatment with iodine. The infectious agent was isolated in pure culture and identified as a *Sporotrichum* sp. producing a black pigment on all solid culture media studied.

The pathology of the disease and the virulence of the sporotrichum will be reported in detail elsewhere.

LITERATURE CITED

1. PAGE, C. G., L. FROTHINGHAM, and J. B. PAIGE. Sporothrix and epizootic lymphangitis. J. Med. Res. 23: 137-150. 1910.
2. PEARSON, L. Epizootic lymphangitis in horses and mules. State Livestock Sanitary Board. Cir. 8. Harrisburg, Pa. 1907.
3. SCHENCK, B. R. On refractory subcutaneous abscesses caused by a fungus possibly related to the sporotricha. Johns Hopkins Hosp. Bul. 9:286-288. 1898.
4. HEKTOEN, L., and C. F. PERKINS. Refractory subcutaneous abscesses caused by *Sporothrix schencki.* A new pathogenic fungus. J. Exp. Med. 5:77-90. 1900.
5. TRIMBLE, W. K., and F. W. SHAW. A case of sporotrichal infection. J. Kansas Med. Soc. 9:305-311. 1909.
6. DE BEURMANN, L., and H. GOUGEROT. Les Nouvelles Mycoses. Gauthier-Villars, Paris. 1910.
7. ————. Les Sporotrichosis. F. Alcan, Paris. 1912.
8. MEYER, K. F., and J. A. AIRD. Various sporotricha differentiated by the fermentation of carbohydrates. J. Inf. Dis. 16:399-409. 1911.
9. DAVIS, D. J. Chromogenisis in cultures of sporotricha. J. Inf Dis. 17: 174-182. 1915.
10. DAVIS, D. J. The formation of chlamydospores in *Sporothrix schenckii.* J. Inf. Dis. 15:483-486. 1915.
11. HYDE, J. N., and D. J. DAVIS. Sporotrichosis in man: with incidental consideration of its relation to mycotic lymphangitis in horses. J. Cut. Dis. 28:321-352. 1910.
12. SUTTON, R. L. Sporotrichosis in man and the horse. Boston Med. and Surg. Journal 164:179. 1911.
13. DAVIS, B. F. Report of a case of sporotrichosis. Surg. Gynec. Obs. 19: 490-91. 1914.
14. MEYER, K. F. Epizootic lymphangitis and sporotrichosis. A.M.A.J. 65: 1675. 1915.
15. BENHAM, R. W., and B. KESTEN. Sporotrichosis—its transmission to plants and animals. J. Inf. Dis. 50:437-458. 1932.

16. FRANK, E. R., and A. D. KIMBALL. A case of sporotrichosis in a jack. Data unpublished. 1941.
17. WENDT, D. O. Sporotrichosis in a jack. Vet. Med. 36:321. 1941.
18. ROBERTS, G. A. Epizootic lymphangitis of solipeds. J.A.V.M.A. 98:226-228. 1941.
19. WICKERHAM, L. J.,and L. F. RETTGER. A taxonomic study of *Monilia albicans* with special emphasis on morphology and morphological variation. J. Tropical Med. and Hyg. June and July Nos. 21 pp. 1939.
20. HARTMAN, T. L. The use of Sudan black B as a bacterial fat stain. Stain Techn. 15:23-28. 1940.
21. DODGE, C. W. *Medical Mycology*. C. V. Mosby, St. Louis, Mo. 1935.
22. BUSHNELL, L. D. Four cases of sporotrichosis in humans. Data unpublished. 1913-1916, and 1920.
23. FOERSTER, H. R. Sporotrichosis—an occupational dermatosis. A.M.A.J. 87:1605-09. 1926.
24. MOORE, J. J., and D. J. DAVIS. Sporotrichosis following mouse bite with certain immunologic data. J. Inf. Dis. 23:252-265. 1918.

Prairie Studies in West Central Kansas: 1941

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INTRODUCTION

The prolonged drought extending from 1933 to 1939 left the native vegetation of the Great Plains region at low ebb. Details of the response of vegetation to this drought period have been reported elsewhere* and reference to these details in this paper will be only incidental to presenting data relative to recovery that occurred during the growing season of 1941. Notes were carefully taken on observations made on plant response throughout the season and the work of charting many meter quadrats, as was done during previous years, was continued in the fall of 1941.

Plants weakened by years of adversity seemed to spring forth with renewed vigor when environmental conditions became more conducive to growth. The purpose of this paper, then, is to present data relative to the improved climatic and soil conditions that prevailed during 1941 and the response of the vegetation to this improvement.

ENVIRONMENTAL CONDITIONS

Precipitation at Hays, Kansas, from 1933 to 1941 is given in Figure 1. Pre-

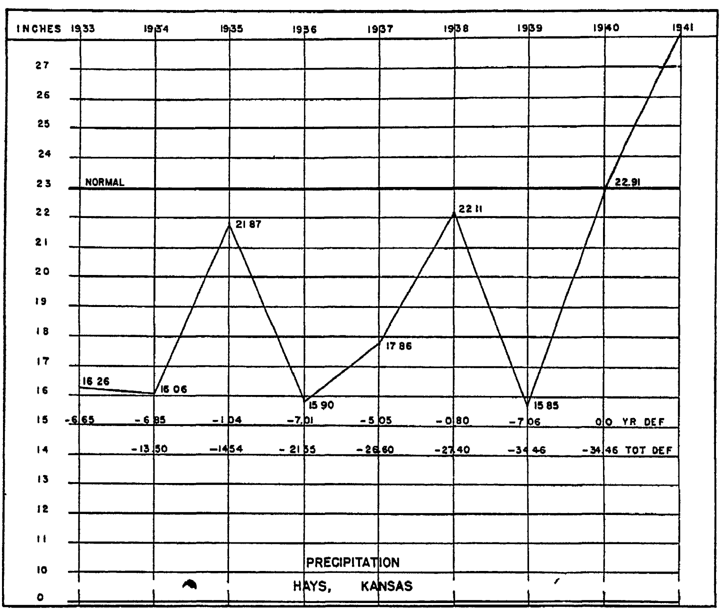


FIGURE 1. Precipitation in inches from 1933 to 1941 as compared to normal.

*"History of the native vegetation of western Kansas during seven years of continuous drought", F. W. Albertson and J. E. Weaver, Ecological Monographs, vol. 12, No. 1, January, 1942.

—Transactions Kansas Academy of Science, Vol. 45, 1942.

soil moisfor all the years from 1933 to 1939 inclusive, was below normal. of the only two of these years (1935 and 1938) did the rainfall even ap- from normal. The total accumulated deficit for the seven-year period was oximately 34.5 inches. The rainfall for 1940 was approximately normal, and for 1941 it was 28.13 inches—approximately 5 inches above normal. The dry spells during 1941 were also of short duration, and consequently much ss intense than they were during the previous years. Increased rainfall was flected in a larger amount of soil moisture (Figure 2). A comparison of the available soil moisture in the upper 5 feet in the short grass type for 1939, 1940, and 1941 reveals the real reason why the native vegetation made such vast improvement during the latter season. Only occasionally during the seasons of 1939 and 1940 was any moisture available above the 4-foot level, and then only in the upper 12 inches. In view of the fact that most native plants did not penetrate the soil to a depth greater than 3 or 4 feet, it is unlikely that the small amount of moisture in the fifth foot was of any value to them. Early spring rains of 1941 furnished a good supply in the upper 2 feet. When determinations were made at the close of April, the moisture had not yet penetrated beyond the 3-foot level. In May there seemed to be no

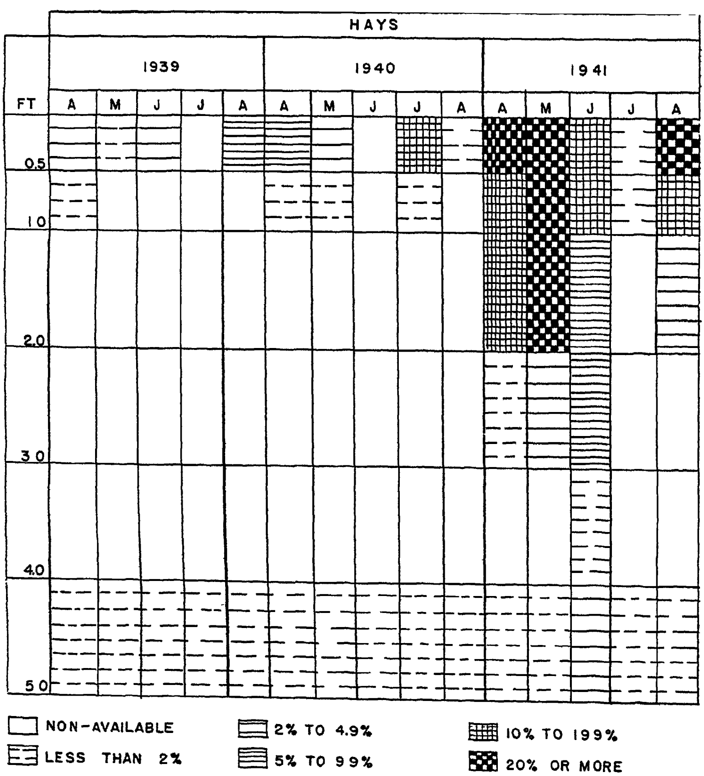


FIGURE 2. Available soil moisture in short grass type at Hays, Kansas.

greater depth of penetration, but rather an increased amount in t... feet. By the end of June, however, a definite connection had be... between the residual moisture below and the surface moisture from... There was a short drought during the month of July which was reflected ... great loss of moisture due to the heavy growth of vegetation. The fall rains beginning in August gradually replenished that which was lost during July, and growth continued late in the fall.

Soil moisture determinations made at Phillipsburg and Dighton, Kansas gave results very similar to those at Hays, except that the dry periods were not of the same intensity, nor at the same time of the growing season. Soil moisture conditions at the other stations in western Kansas were doubtless very similar to those at Hays.

RESPONSE OF VEGETATION TO IMPROVED ENVIRONMENT

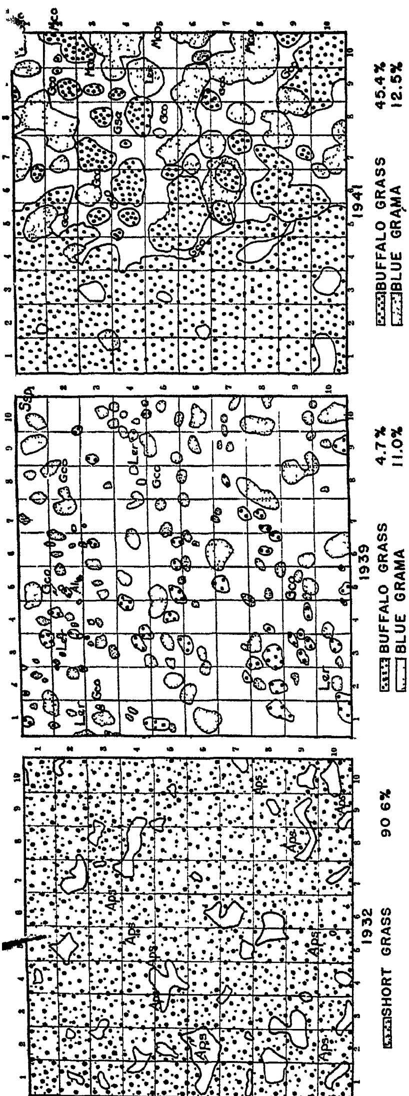
The improvement in basal cover is shown in a general way for the short grasses at Hays, (Table 1). The average cover of all quadrats in 1939 was 22.1 percent. It had been decreased to 18.9 percent in 1940, but increased to over 55 percent in 1941. There were no significant differences in the total average cover for the ungrazed and moderately grazed conditions in 1939 and 1940. The cover, however, for the heavily grazed condition was significantly less than those ungrazed and moderately grazed. Great improvement occurred in all quadrats, regardless of condition, in 1941. It is interesting to note that buffalo grass nearly always constituted a smaller percentage of cover than its co-dominant, blue grama, for the seasons of 1939 and 1940. This difference is doubtless due to the fact that blue grama grass is slightly more resistant to drought than buffalo grass. However, the ability of the buffalo grass to recover from the shock of the drought is much greater than that of blue grama. This recovery is indicated by its vastly increased cover in 1941. It was not uncommon for large areas, several yards in diameter, devoid of all vegetation except occasional bunches of blue grama and buffalo in 1940, to become almost solidly covered by the rapid growth of buffalo grass during the 1941 growing season.

The shift in basal cover is shown in more detail in Figure 3. The basal cover for this representative meter quadrat is shown for 1932 before the drought began; in 1939 when the drought was at its worst, and again in 1941 after one year of abundant rainfall. The cover of approximately 90 percent in 1932 was made up of approximately equal proportions of buffalo and blue grama grass. As the drought progressed, buffalo grass suffered much greater loss than did blue grama grass. This loss is indicated in the cover for 1939. It is interesting to note, however, where the gain was made in 1941, when

TABLE I—Percent basal cover of buffalo grass (Bda) and blue grama grass (Bgr) on pastures under different conditions during three years at Hays, Kansas.

Condition		Percent basal ground cover 1939	1940	1941
Ungrazed	Bda	9.3	9.2	41.3
	Bgr	13.0	10.3	13.9
	Total	22.3	19 5	65.2
Moderately grazed	Bda	12.3	9.1	25.8
	Bgr	14.4	14.8	15.5
	Total	26.7	23.9	41.5
Heavily grazed	Bda	9.8	6.1	40.9
	Bgr	7.4	7.4	17.8
	Total	17.2	13.5	58.7
Average cover of all quadrats	All grasses	22.1	18.9	55.1

sture was plentiful. During this two-year interim (1939-1941) much blue grama grass, through drought and competition, was eliminated portion of this meter quadrat. Blue grama gained from 11 percent to 12.5 percent between 1939 and 1941. During the same time buffalo grass gained from 4.7 percent to 45.4 percent. This gain is fairly typical of the



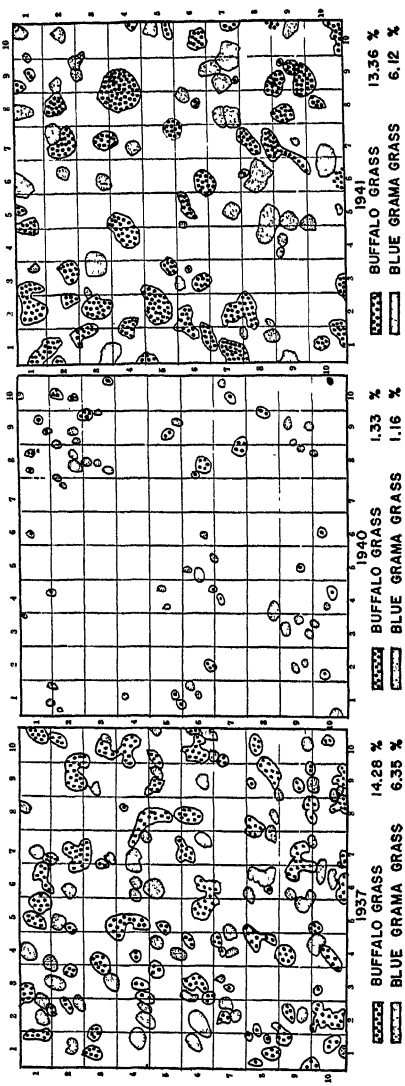


FIGURE 3. Typical meter quadrat in short grass habitat at Hays, Kansas. All symbols refer to native forbs found in the area when the charting was done.

FIGURE 4. Typical meter quadrat in short grass pasture at Oakley, Kansas.

ability of buffalo grass to revegetate an area under favorable environmental conditions.

The basal cover of the second group of prairies studied in west-central Kansas, is presented in Table 2. These prairies are arranged in order from the best to the worst conditions to which they had been previously subjected. The average cover of all prairies was 17.6 percent in 1939. This cover had been reduced to 6.4 percent in 1940. The favorable growing conditions during 1941, however, brought about rapid recovery in every pasture studied, except in those places where every vestige of vegetation had been eliminated in 1939. The average cover for all quadrats in 1941 was 35.3 percent. There was great variation between the pastures that were lightly dusted and moderately grazed and those heavily dusted and heavily grazed.

TABLE II—Percent basal cover of buffalo grass (Bda) and blue grama grass (Bgr) under various conditions and at different stations in West-central Kansas.

Station and Condition		Percent basal ground cover 1939	1940	1941
QUINTER	Bda	35.3	3.4	42.7
Lightly dusted and	Bgr	2.2	1.7	21.9
moderately grazed	Total	37.5	5.1	64.6
OAKLEY	Bda	5.0	1.3	13.4
Lightly dusted and	Bgr	5.4	1.2	6.1
moderately grazed	Total	10.4	2.5	19.5
QUINTER	Bda	14.9	3.4	24.8
Lightly dusted and	Bgr	17.1	11.5	14.9
heavily grazed	Total	32.0	14.9	39.7
OAKLEY	Bda	3.7	1.0	3.1
Lightly dusted and	Bgr	16.0	3.9	17.4
heavily grazed	Total	19.7	4.9	20.5
QUINTER	Bda	7.7	1.6	10.0
Heavily dusted and	Bgr	9.4	3 5	12.5
moderately grazed	Total	17.1	5.1	22.5
NESS CITY	Bda	8.4	3.6	34.7
Heavily dusted and	Bgr	9.4	7.9	15.1
moderately grazed	Total	17.8	11.5	49.9
DIGHTON	Bda	2.5	5.5	38.2
Heavily dusted and	Bgr	3.9	1.4	6.8
moderately grazed	Total	6.4	6.9	45.0
DIGHTON	Bda	0.0	0.0	0.6
Heavily dusted and	Bgr	0.0	0.0	0.0
heavily grazed	Total	0.0	0.0	0.6
Average cover for all quadrats	All grasses	17.6	6.4	35.3

A typical meter quadrat in a prairie located near Oakley, Kansas, is shown in Figure 4. In 1937 the cover of buffalo grass was 14 3 percent, as compared to 6.4 percent for blue grama grass. By the fall of 1940 the cover of both grasses had been materially reduced, and at this time neither grass had a cover of as much as 2 percent. The cover, when charted in the fall of 1941, was found to be over 13 percent for buffalo grass and slightly over 6 percent for blue grama grass.

Farther to the west is a third group of prairies, the cover of which is shown in Table 3. In 1939 the cover averaged 13.2 percent on all the quadrats studied; in 1940, 6.5 percent and in 1941, 18 4 percent. It is significant to note that there was a material reduction between 1939 and 1940, and then a rapid gain during the season of 1941. This condition is shown in more detail in a representative quadrat located near Tribune, Kansas (Figure 5). In 1937 blue grama had a cover of 1.55 percent. In the fall of 1940 the cover of this grass had been increased to 5.4 percent, in addition to a small amount of sand

TABLE III—Percent basal cover of buffalo grass (Bda), blue grama grass (Bgr), and sand dropseed (Scr) under various conditions and at different stations in Western Kansas.

Station and Condition		Percent basal ground cover 1939	1940	1941
SCOTT CITY	Bda	1.7	0.4	2.4
Lightly dusted and	Bgr	9.0	0.0	8.0
moderately grazed	Total	10.7	0.4	10.4
MARIENTHAL	Bda	15.7	1.7	23 7
Lightly dusted and	Bgr	1.7	0.9	2.8
moderately grazed	Total	17.4	2.6	26.5
TRIBUNE	Bda	6.0	5.8	7.4
Lightly dusted and	Bgr	24.2	14.7	24.8
moderately grazed	Total	30.2	20.5	32.2
TRIBUNE	Scr	0.2	0.3	2.1
Heavily dusted and	Bgr	5.2	5.5	12.7
moderately grazed	Total	5.4	5.8	14.8
TRIBUNE	Scr	0.2	0.7	5.3
Heavily dusted and	Bgr	2.2	2.7	2.8
moderately grazed	Total	2.4	3.4	8.1
Average cover of all quadrats	All grasses	13.2	6.5	18.4

dropseed. When charted in the fall of 1941, the cover of blue grama had been increased to 12.7 percent and that of sand dropseed to 2 percent.

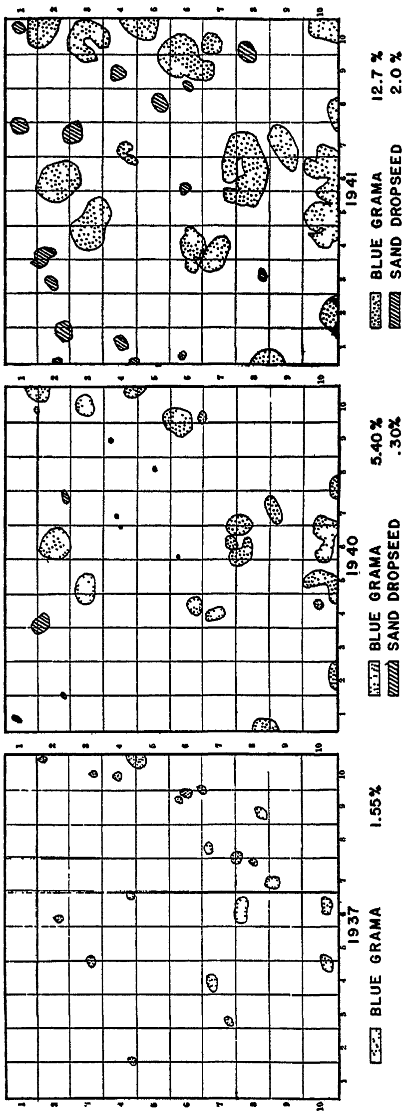
The cover in the last group of prairies located far to the southwest is found in Table 4. In 1939 the average cover of all quadrats was only 3.9 percent. This had been reduced to zero in 1940. The few half dead crowns that evidently remained but escaped the attention of the one who charted, furnished a cover of only 2.3 percent in the fall of 1941. A quadrat located near Syracuse, Kansas, and typical of this condition is shown in Figure 6. The cover in 1937 when first charted was slightly over 6 percent, and was divided rather equally between blue grama grass and buffalo grass. The drought of 1939 had completely annihilated these short grasses and nothing but seedlings of sand dropseed could be found in the fall of 1940. In the fall of 1941, sand dropseed constituted only .71 percent, and the one small bunch of blue grama only .14 percent.

FORBS

The decrease in the number of forbs during the drought lagged considerably behind that of the grasses. Likewise, when favorable growing conditions returned in 1941, the increase in the number of forbs was much slower in getting under way than were the grasses. In fact, large areas in short grass pastures were totally devoid of most of the forbs that were important before and during the early part of the drought. Such native species as few-

TABLE IV—Percent basal cover of buffalo grass (Bda) and blue grama grass (Bgr) under various conditions and at different stations in southwest Kansas.

Station and Condition		Percent basal ground cover 1939	1940	1941
HOLCOMB	Bda	0.0	0.0	4.8
Lightly dusted and	Bgr	0.0	0.0	3.4
moderately grazed	Total	0.0	0.0	8.2
SYRACUSE	Bda	11.7	0.0	0.01
Lightly dusted and	Bgr	2.8	0.0	0 63
moderately grazed	Total	14.5	0 0	0.65
SYRACUSE	Bda	0.0	0.0	0.0
Heavily dusted and	Bgr	0.0	0.0	0.0
heavily grazed	Total	0.0	0.0	0 0
LAKIN	Bda	0.0	0.0	0.0
Heavily dusted and	Bgr	0.2	0.0	0.3
heavily grazed	Total	0.2	0.0	0 3
Average cover of all quadrats	All grasses	3.9	0.0	2.3



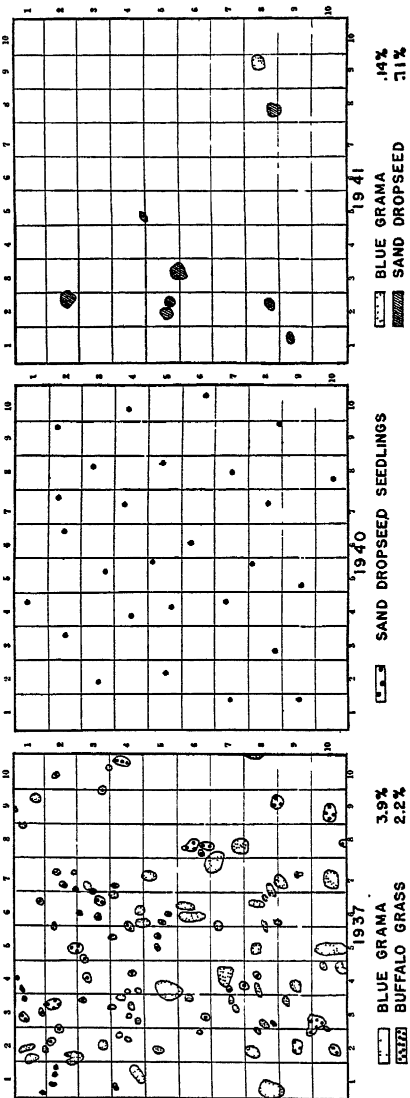


FIGURE 5. Typical meter quadrat in short grass pasture at Tribune, Kansas.
FIGURE 6. Typical meter quadrat in short grass pasture at Syracuse, Kansas.

flowered Psoralea (*Psoralea tenuiflora*), spiny Sideranthus (*Sideranthus spinulosus*), narrow-leafed four o'clock (*Allionia linearis*), and the blazing star (*Liatris punctata*), made some gains during the season of 1941, but it was not uncommon to find them completely absent from some of the short grass pastures. It is interesting to note, however, that the prairie cone flower (*Ratibida columnaris*), which had been absent since early in the drought

period, returned with great vigor upon the advent of favorable growing conditions; in fact, in many prairies the seedlings of this species were the most abundant of all forbs. No noticeable change was observed in the status of the false red mallow (*Malvastrum coccineum*) and the common thistle (*Cirsium undulatum*).

WEEDS

The more favorable environmental conditions during 1941 were reflected in a great increase in the number and stature of the common annual weeds of the prairie. Little barley (*Hordeum pusillum*), pepper grass (*Lepidium densiflorum*), sticktight (*Lappula occidentalis*), Russian thistle (*Salsola pestifer*), pig weeds (*Amaranthus spp.*), and lamb's quarter (*Chenopodium spp.*) were frequently found to constitute the major part of the vegetation. On many occasions half-starved plants of the native grasses were found with considerable difficulty among the numerous weeds that far overtopped them.

CONCLUSION

The greatest gain in cover occurred on the eastern portion of the area studied. Even to the west the increase was significant where a remnant of the parent vegetation remained from which young shoots could spring upon the advent of better growing conditions.

5

Evaluation of Species of Prairie Grasses as Interplanting Ground Covers on Eroded Soils

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INTRODUCTION

For the purpose of hillculture studies, five stations have been established in various locations in the United States. One of these projects initiated by the office of Research of the Soil Conservation Service in July, 1937, is located at the Hillculture Field Station at Floris, Iowa.

One of the basic principles of hillculture practices is the conservation of water by contour cultivation. The hillculture plants of economic value are then grown on these contour strips under conditions of medium cultivation. The growing of permanent cover crops between the cultivated strips for the control of soil and water loss is necessary under this method of culture. The investigation of methods of establishment and the evaluation of native prairie grasses as cover crops is the purpose of this research sub-project at the Hillculture Field Station.

EXPERIMENTAL

The grasses used were most of the true prairie and tall-grass prairie dominants. The two most important dominants of the short grass plains, buffalo grass and blue grama grass, were also included especially because of the possibility of their establishment on badly eroded soils in extremely dry sites.

TABLE I—Species of grasses selected and planted in the experimental strips.*

Scientific name	Common names
Agropyron smithii Rydb.	Western wheatgrass, bluestem
Andropogon furcatus Muhl.	Big bluestem, bluejoint, turkeyfoot
Andropogon scoparius Michx.	Little bluestem, prairie beardgrass
Bouteloua curtipendula (Michx.) Torr.	Side-oats grama
Bouteloua gracilis (H.B.K.) Lag.	Blue grama
Buchloe dactyloides (Nutt.) Engelm	Buffalo grass
Elymus canadensis L.	Canada wild-rye
Koeleria cristata (L.) Pers.	Junegrass
Panicum virgatum L.	Switchgrass
Sorghastrum nutans (L.) Nash	Indian grass
Sporobolus asper (Michx.) Kunth.	Dropseed
Stipa spartea Trin.	Porcupine grass

Four locations of terrace strips on a slope of approximately 10 to 30 per cent were picked for mixture and pure seedings. The first of these is a gradual south slope. The soil type is Lindley loam with a surface soil of 1 to 3 inches. The terrace strips were made by plowing back-furrowed strips 8 feet wide on the contour. These narrow areas (like diversion ridges) have open furrows both above and below the plowed ground. The strips vary in length from 50 to 150 feet. Buffer strips of the original cover, left between the plowed areas, were covered with a dense vegetation of sweet clover.

The second location has considerable variation from a severely eroded and depleted condition on the upper 10 strips to a soil with 2 to 4 inches of the A horizon remaining on the lower three strips. These strips are approximately 50 to 200 feet long. Canada bluegrass (*Poa compressa*) and poverty grass

*A. S. Hitchcock *Manual of Grasses of United States* used as authority for nomenclature.

(*Aristida oligantha*) made up the major part of the original vegetative cover. The method of preparation of the ground was the same as that used in the first site.

As a further check on the type of preparation best suited to the establishment of native grasses, a third and fourth site were prepared with minimum preparation of the soil. The ground was double-disked to loosen the surface layer of soil. These two locations were put in an unfurrowed slope with a somewhat similar cover and soil fertility to that in the second site except that the soil was more uniformly depleted throughout all of the strips. The soil type was Lindley loam with an outwash mixture of A and B horizons. The grass seed in all four sites was broadcast by hand and then harrowed into the soil with one section of a harrow. The plantings were completed the first week of May, 1939.

In the last three years basal area measurements have been made in permanent quadrats which were laid out in the contour grass strips. In addition to these basal area studies 1/4000 acre quadrats were set up from which yield tests were taken. It is hoped that through the use of permanent quadrats for yield tests and basal area measurements that the development of these grasses on the several sites can be shown over a period of years.

TABLE II—Comparisons of basal area (in percent) of five grass mixtures grown on contour strips on eroded land in Southern Iowa, 1939, 1940, and 1941.

Species	Site	1939	1940	1941
Sorghastrum nutans		1.33	2.91	0.71
Andropogon furcatus	1	0.33	---- ----	0.02
Panicum virgatum		0.24	1.02	2.47
Total		1.90	3 93	3.20
Bouteloua curtipendula		2.67	4.35	5.64
Andropogon scoparius		0.63	0.70	0.85
Sporobolus asper	1	0.60	0.71	0.32
Muhlenbergii racemosa		---- ----	0.72	0.41
Stipa spartea		0.07	0.02	1.37
Total		3.97	6.50	8.59
Bouteloua curtipendula		0.62	2.74	5.39
Andropogon scoparius		0.99	1.96	4.59
Panicum virgatum	2	---- ----	0.18	1.30
Stipa spartea		0.17	0.06	0.14
Bouteloua gracilis		---- ----	0.06	---- ----
Sporobolus asper		---- ----	0.03	---- ----
Total		1.78	5.03	11.42
Bouteloua gracilis		0.85	1.29	2.47
Andropogon scoparius	3	0.56	1.84	4.53
Total		1.41	3.13	7.00
Bouteloua gracilis		9.75	8.17	14.68
Andropogon furcatus	4	0.50	1.97	3.61
Total		10.25	10.14	18.29

Table 2 shows the results of basal area measurements of several of the grass mixtures grown on the contour strips. There are several important things to point out in this table. In the tall grass mixture *Panicum virgatum* has shown a gradual increase in growth but the total basal area for the three grasses is less in the fall of 1941 than it was the previous year. A number of factors may contribute to the change in the equilibrium such as soil moisture, soil fertility, root development, and temperature.

The upland mixture of five grasses in site 1 show a gradual increase in total basal area. Side-oats grama has more than doubled its basal area during

the last two growing seasons. The mixture of six grasses in site 2 has made the greatest increase in growth of any of the mixtures, that is, 1.78 percent in 1939 as compared to 11.42 percent basal area in 1941. Here again side-oats grama was dominant. In site 3 both blue grama and little bluestem show an increase with the bluestem somewhat more abundant. A more striking example is the mixture of *Bouteloua gracilis* and *Andropogon furcatus* in site 4. The results for 1941 show considerable increase over the basal area of the previous two years.

Table 3 is an average of six species planted in pure stands on the strips. On this basis little bluestem rates highest for the three years. It would appear to have reached the climax of its development by 1941, however that remains to be seen in future observation and measurement. Both big bluestem and porcupine grass appear to have reached the height of their development in 1940 since both show less basal area in 1941 than in the year before.

TABLE III—Comparisons of the basal area, in percent, of the six prairie grasses grown twenty contour strips in 1939, 1940 and 1941 at the Hillculture Experimental Farm.

Species	1939	1940	1941
Andropogon scoparius	2.32	6.03	11.31
Panicum virgatum	2.03	5.68	6.52
Sorghastrum nutans	1.60	5.30	6.06
Bouteloua gracilis	2.17	5 05	5.88
Andropogon furcatus	1.78	4.96	4.39
Stipa spartea	1.28	2.74	1.79

TABLE IV—Weight comparisons of 1/4000 acre clip quadrats in pounds per acre from contour strips, November 1940. The lowland grass mixture contains *Andropogon furcatus, Sorghastrum nutans, Panicum virgatum,* and *Elymus canadensis.* The upland mixture consists of *Andropogon scoparius, Sporobolus asper, Bouteloua curtipendula, and Bouteloua gracilis.*

Species	Site 1	Site 2
Andropogon furcatus	5986	5840
Andropogon scoparius	3796	5256
Sorghastrum nutans	5440	6970
Panicum virgatum	8832	2392
Bouteloua gracilis	2431	2729
Stipa spartea	2210	1360
Lowland mixture	5810	4482
Upland mixture	5280	4752

Table 4 shows the yield of grasses per acre on a dry-weight basis computed from weight-list quadrats. These estimated yields were taken in the fall of 1940. The greatest single yield was obtained in a strip of *Panicum virgatum.* A wide variation is seen between the yields of switch grass in site 1 and site 2; 8832 and 2392 pounds per acre respectively. The difference can readily be accounted for in that the switch grass in site 1 apparently is resistant to stem rust while that in site 2 is not. The seed sown in these two strips was obtained from different sources.

The highest yielding grass in site 2 is *Sorghastrum nutans* with a yield of 6970 pounds. This particular strip was located near the bottom of the slope but somewhat above the strip plantings of *Andropogon furcatus* and *Andropogon scoparius and* slightly more eroded. *Bouteloua gracilis* ranks rather low in yield in comparison to its basal area. However blue grama is the only short grass in the group studied and produces a very satisfactory ground cover on thin eroded soils with little site preparation. *Stipa spartea* is the lowest yielder in all instances. It likewise ranks low in basal area measurements.

In view of the fact that basal area for native grasses of the north central states growing on virgin soil range from 7 to 20 percent, a basal area cover of 6 to 18 percent the third year for pure seedings and mixtures of native

grasses constitutes a very adequate establishment response. One of the important problems in hillculture research is the rapid establishment of plants suitable for erosion control. Since it has been shown from the above data that selected prairie grasses can be established on hilly and eroded soils it is hoped that they will prove valuable in hillculture practices. Kentucky bluegrass has not been satisfactory as an interplanting cover, since it has been difficult to get it established in areas most in need of this cover. Not only do Indian grass, switch grass, little and big bluestem appear to furnish adequate cover to reduce erosion to a minimum on sloping ground but they also produce comparatively large yields of organic matter which can be used as mulching on the cultivated strips between the grasses.

6

Myxomycetes of Kansas—II[1]
Stemonitales

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The following paper on the Stemonitales is the second in a series of studies of the Myxomycetes of Kansas(1). Although members of the Physarales were collected abundantly and were better known to the writer, members of the Stemonitales were frequent. Collecting and taxonomic difficulties hindered the gathering of sufficient materials for a comprehensive study, nevertheless these descriptions are brought together as a possible basis for future investigations.

KEY TO GENERA OF STEMONITALES

1. Deposits of lime present in the stalk and columella..........................10. Diachea.
1. Deposits of lime absent.
   2. Capillitium arising over the entire length of the columella; sporangium wall usually evanescent.
      3. Capillitial branches anastomosing to form a surface net; sporangia usually closely crowded. ....11. Stemonitis.
      3. Capillitial branches usually free at the tips; sporangia gregarious or scattered, a few species closely crowded. ....12. Comatricha.
   2. Capillitium arising from the tip of the columella, poorly developed in some genera; sporangium wall usually more or less persistent.
      3. Columella almost or entirely traversing the sporangium.
         4. Columella entirely traversing the sporangium, forming an expanded disc at the apex from which the capillitium originates. ....13. Enerthenema.
         4. Collumella entirely traversing the sporangium or dividing above into a few simple branches. ....14. Macbrideola.
      3. Columella seldom reaching beyond the center of the sporangium.
         4. Spores colorless; sporangia very minute................15. Echinostelium
         4. Spores dark.
            5. Capillitium forming an intricate network; sporangium wall usually a persistent membrane. ....16. Lamproderma.
            5. Capillitium of sparingly branched threads bearing persistent fragments of the sporangium wall on their tips. ....17. Clastoderma

GENUS 10. DIACHEA FRIES

Sporangia stalked or sessil. Sporangium wall membranous, more or less

[1]Contribution No. 435, Department of Botany and Plant Pathology; a portion of the dissertation presented in partial fulfillment of the Degree of Master of Science at Kansas State College, 1941. The writer wishes to express his appreciation to Dr. F. C. Gates, Department of Botany and Plant Pathology, Kansas State College, for his invaluable aid in the preparation of this paper: and to Mr. Robert Hagelstein, New York Botanical Garden, and to Dr. G. W. Martin, Department of Botany, State University of Iowa, for authentic specimens of many species, and for identification or verification of most of the species reported in this paper.

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persistent, without deposits of lime. Stalk calcareous. Columella usually well developed, calcareous. Capillitium without deposits of lime.

KEY TO SPECIES OF DIACHEA

1. Sporangia cylindrical. ....1. D. leucopodia.
1. Sporangia globose to ovoid.
   2. Spores reticulated with lines of fine warts; sporangia short stalked. ....2. D. subsessilis.
   2. Spores bearing dark brown, cylindrical protuberances up to 1.5 mu in length. ....3. D. splendens.
   2. Spores strongly spinulose. ....4. D. bulbillosa.

1. DIACHEA LEUCOPODIA (BULL.) ROST.

Total height 0.5-1.2 mm. Sporangia gregarious, short stalked, cylindrical, occasionally ellipsoid, iridescent until dehiscence of sporangium wall, then dark brown. Sporangium wall colorless, membranous, somewhat rugose, more or less persistent, especially below. Stalk white, calcareous, 0.2-0.4 mm in length. Hypothallus white, scanty or none. Columella white, calcareous, slender, reaching nearly to the apex of the sporangium. Capillitium a lax network of brown threads with pale tips. Spores dark brown in mass, dull violaceous by transmitted light, globose, minutely warted, 9-10 mu in diameter.

Commonly fruiting on strawberry plants, raspberry canes, dead leaves and twigs, etc. Riley and Geary Counties.

2. DIACHEA SUBSESSILIS PECK

Sporangia gregarious, short stalked or sessil, globose, 0.2-0.5 mm in diameter, iridescent blue or violet. Sporangium wall thin, membranous, colorless, somewhat persistent. Stalk white, stout, calcareous, 0.1-0.3 mm in length. Hypothallus scanty, white, calcareous, often obsolete. Columella white, conical or nearly obsolete, calcareous. Capillitium a lax network of slender, branching and anastomosing, violaceous brown to nearly colorless threads radiating from the columella. Spores in mass dark brown, violaceous green (color results from the blending of the violet color of the epispore with the pale yellow color of the spore protoplast) by transmitted light, globose, reticulated with lines of fine warts, 9.4-11 mu in diameter.

On fallen leaves. Geary and Riley Counties.

3. DIACHEA SPLENDENS PECK

Sporangia gregarious, stalked, rarely sessil on a more or less continuous, white, calcareous hypothallus, globose to subglobose, blue with violet tints, brilliantly iridescent, 0.2-0.5 mm in diameter. Sporangium wall thin, membranous, colorless, rugose, somewhat persistent. Stalk white, calcareous, stout, tapering upwards or even, 0.3-0.8 mm in length. Hypothallus usually scanty or none. Columella white, cylindrical, obtuse, extending beyond the center of the sporangium, calcareous. Capillitium a network of slender, branching and anastomosing, dark brown threads radiating from the columella, colorless as they leave the columella and pale at the tips. Spores nearly black in mass, violet- brown by transmitted light, bearing dark brown cylindrical protuberances up to 1.5 mu in length, also marked with a faint grayish reticulation, and usually with scattered warts, 7.8-9.4 mu in diameter.

Collected in abundance on leaves, twigs, and moss. Geary County.

4. DIACHEA BULBILLOSA (BERK. & BR.) Li.

Sporangia gregarious, stalked, rarely sessil, globose to ovo. diameter, often brilliantly iridescent. Sporangium wall thin, n colorless, rugose, somewhat persistent, falling away in large fragme.. white, calcareous, shining, broad at the base, narrowing rapidly upw. 0.4-0.6 mm in length. Hypothallus scanty or none. Columella clavate, rea' ing nearly to the apex of the sporangium, white, calcareous. Capillitiu branching and anastomosing to form a lax network of slender purple-brown threads which are pale at the tips, radiating from the columella. Spores nearly black in mass, grayish violet by transmitted light, globose, strongly spinulose, also marked by a faint grayish reticulation, 8.3-11 mu in diameter.

On fallen leaves and wood. Riley County.

D. splendens, which was considered a variety of *D. bulbillosa,* seems to be a distinct, but closely related species. The two species may be identified with the unaided eye. Sporangia of *D. splendens* are distinctly blue, whereas the sporangia of *D. bulbillosa* are bluish gray.

GENUS 11. STEMONITIS GLEDITSCH EMEND. ROST.

Sporangia closely crowded, stalked, cylindrical. Sporangium wall evanescent. Stalk setaceous, continuing almost to the apex of the sporangium as a columella. Capillitium arising along the entire length of the columella, branching and anastomosing at the surface of the sporangium to form a surface net.

KEY TO SPECIES OF STEMONITIS

1. Spores reticulate.
   2. Sporangia 5-8 mm tall, brown. ....1. S. fusca.
   2. Sporangia up to 3 mm tall, dark brown to nearly black. ....2. S. nigrescens.
1. Spores spinulose, warted to nearly smooth.
   2. Spores less than 7 mu in diameter.
      3. Spores 5.5-7 mu in diameter. ....3. S. axifera.
      3. Spores 4.4-5 mu. in diameter. ....4. S. smithii.
   2. Spores more than 7 mu in diameter.
      3. Total height 10-19 mm; sporangia flexuose. ....5. S. splendens.
      3. Total height less than 10 mm; sporangia upright.
         4. Surface net with meshes 10-60 mu wide; spores brown by transmitted light. ....6. S. webberi.
         4. Surface net delicate; spores pale violaceous brown.
            5. Columella often with platelike expansions at the apex. ....7. S. flavogenita.
            5. Columella without platelike expansions; sporangia usually in small scattered clusters on leaves and herbaceous stems. ....8. S. herbatica.

1. STEMONITIS FUSCA ROTH

Total height 5-8 mm. Sporangia crowded into tufts, flexuose, cylindrical, stalked, brown. Stalks 1.5-2.2 mm in length, black, occasionally brown, slender. Hypothallus dull red near the base of the stalk, otherwise colorless, shining, somewhat iridescent. Columella slender, dissolving into the capillitium just below the apex of the sporangium. Capillitium of abundant purple-brown threads giving rise to the delicate, spinulose or smooth, brown surface net with

..ross. Spores in mass some shade of brown, violaceous by ..., globose, marked with reticulations of spines which are often ..y ridges, 6-9 mu in diameter.

..on on wood. Occasionally found fruiting on dead attached leaves of ..a. Douglas, Harvey, Lyon, Geary, and Edwards Counties.

Collections from Edwards County in which the surface net is poorly deeloped may represent *S. fusca* matured under adverse conditions.

2. STEMONITIS NIGRESCENS REX

Total height 1.4-3 mm. Sporangia in somewhat dense clusters up to 1 cm across, stalked, erect, cylindrical, dark brown to nearly black. Stalk 0.1-0.8 mm. in length. Hypothallus continuous, membranous, reddish brown. Columella slender, black, tapering upwards, reaching the apex of the sporangium. Capillitium a loose network of dark brown threads springing from all parts of the columella, ultimately branching and anastomosing into a delicate surface net with many free ends; meshes irregular, varying from 3-20 mu across, often imperfectly developed in the upper part of the sporangium. Spores dark brown in mass, violaceous brown by transmitted light, globose, reticulated with rows of spines, 8-9.5 mu in diameter.

Not uncommon on wood. Geary County.

3. STEMONITIS AXIFERA (BULL.) MACBR.

Total height 6-8 mm. Sporangia in small clusters, cylindrical, stalked, reddish brown. Stalks 2 mm long, black, slender, even, rising from a continuous hypothallus. Columella slender, black, tapering upwards and dissolving into the capillitium well below the apex of the sporangium. Capillitium of brown threads forming a network of medium density; surface net with many short, free threads, brown, with meshes 7-40 mu wide. Spores almost colorless by transmitted light, globose to slightly oval, spinulose to almost smooth, 5.5-7 mu in diameter.

Not uncommon on wood. Douglas, Harvey, and Geary Counties.

4. STEMONITIS SMITHII MACBR.

Total height 1.5-2.5 mm. Sporangia in dense clusters usually less than 6 mm across, erect, stalked, cylindrical, brown with a reddish cast. Stalks 0.4-1 mm in length, black, slender, even. Hypothallus continuous, membranous, brown. Columella slender, black, dissolving into the capillitium just below the apex of the sporangium. Capillitium a moderately dense network of brown threads giving rise to a delicate, pale brown surface net. Spores pale by transmitted light, globose, with wall thinner on one side, nearly smooth, 4.4-5 mu in diameter.

A single collection on wood in Geary County.

S. smithii seems closely related to *S. axifera,* and may be merely a phase of the latter species. *S. smithii* differs in the smaller size and smaller spores.

5. STEMONITIS SPLENDENS ROST.

Total height 10-19 mm. Sporangia closely fasciculate, usually in large clusters, flexuose, stalked, sometimes almost sessil, narrowly cylindrical, brown, often purplish brown after dispersion of spores. Stalks 2.5-3.5 mm in length, black, shining, slender. Hypothallus continuous, thin, membranous, silvery, or where thicker reddish brown in color. Columella ending somewhat abruptly at or just below the apex of the sporangium. Capillitium composed of brown to purplish brown threads arising at intervals along the columella, or

branching and anastomosing to form a loose network, often with numerous membranous expansions; surface net smooth, pale brown to purplish brown, with meshes 7-65 mu wide. Spores pale violet-brown by transmitted light, globose, often with wall thinner on one side, evenly warted, 7-9 mu in diameter.

Common on wood. Douglas, Geary, and Riley Counties.

In several collections which seem to have developed under adverse conditions the sporangia are sessil or nearly so, 3-4 mm tall, and upright or somewhat weak. The surface net is usually as in the typical form, but is often poorly developed.

Lister considered forms of *S. splendens* having the meshes of the surface net 80-100 mu across as the variety *webberi* (3). Macbride and Martin (4) described *S. webberi* Rex as usually 8-10 mm tall, but occasionally 5-15 mm tall; capillitium open, with surface net pale, the meshes large, irregular, and 50-125 mu wide; spores yellowish brown or lilaceous brown by transmitted light, minutely verruculose, 8-9 mu in diameter.

Several collections agreeing with *S. splendens* in all other respects have meshes of the surface net 30-100 mu across.

6. STEMONITIS WEBBERI REX

Total height 1.5-3.5 mm. Sporangia loosely clustered, often in large colonies, stalked, erect, cylindrical, 0.3-0.4 mm in diameter, purple-brown. Stalk dark red to nearly black, setaceous, 0.5-1.0 mm in length. Hypothallus more or less continuous, thin, membranous, colorless, reddish near base of stalk, somewhat iridescent. Columella slender, dissolving into the capillitium at the apex of the sporangium or often ending abruptly below the apex, sometimes ending with a membranous expansion. Capillitium lax, purple-brown, springing from all parts of the columella; surface net irregular, with few peridial processes, with meshes varying from 10-60 mu across. Spores dark brown in mass, brown by transmitted light, globose to slightly ovoid, warted, 9-11 mu in diameter.

On decaying wood. Geary and Riley Counties.

7. STEMONITIS FLAVOGENITA JAHN

Total height 7-9 mm. Sporangia closely crowded in small clusters, stalked, cylindrical, ferruginous. Stalk slender, black, about 2 mm in length, arising from a continuous, brown hypothallus. Columella slender, black, tapering upwards and reaching the apex of the sporangium, there often expanded into a membranous plate. Capillitium of brown threads springing from all parts of the columella forming a loose network with many membranous expansions; surface net even, with meshes 4-22 mu across, brown. Spores pale violaceous brown by transmitted light, globose, minutely and faintly warted, 7-9.5 mu in diameter.

On wood. Edwards County.

The material described is scanty, but is probably this species.

8. STEMONITIS HERBATICA PECK

Total height 1.4-5 mm. Sporangia in small clusters, erect, stalked, sometimes almost sessil, cylindrical, brown, sometimes interspersed with small, globose or oblong sporangia. Stalk 0.4-1.0 mm in length, black, shining, slender, nearly even, arising from a continuous, membranous hypothallus which is almost imperceptible except near the base of the stalk where the hypothallus is red-

dish in color. Columella black, slender, narrowing upwards, dissolving into the capillitium near the apex of the sporangium. Capillitium a loose or somewhat dense network of brown threads, often with many membranous expansions; surface net delicate, pale brown, spinulose or smooth, with meshes 8-22 mu across. Spores pale violaceous brown by transmitted light, globose, minutely and closely warted, 8.3-9 mu in diameter.

Not uncommon on dead leaves, herbaceous stems, and occasionally on wood. Geary, and Riley Counties, and the Fort Riley Reservation. Sometimes occurring in large, dense colonies on sweetpotato sprouts in cold frames.

GENUS 12. COMATRICHA PREUSS EMEND. ROST.

Similar to the genus Stemonitis but usually lacking the definite surface net, and in the sporangia not usually being in dense clusters. Some of the species approach the genus Lamproderma but differ in the absence of the more or less persistent sporangium wall.

Key to Species of Comatricha

1. Sporangia closely crowded.
    2. Sporangia weak, 7-14 mm in length; spores spinulose, the spines forming a close reticulation. ....1. C. longa.
    2. Sporangia erect, 1.5-2 mm tall; spores spinulose to nearly smooth. ....2. C. irregularis.
1. Sporangia gregarious to scattered but not closely clustered.
    2. Capillitium simple, with few or no anastomoses; sporangia minute.
        3. Capillitium a small tuft of nearly simple threads with clavate tips. ....3. C. fimbriata.
        3. Capillitium of a few rigid, branching, but scarcely anastomosing threads. ....4. C. cornea.
    2. Capillitium intricate.
        3. Capillitium arising from the tip of the short columella.
            4. Spores purplish brown by transmitted light........5. C. elegans.
            4. Spores reddish violet by transmitted light.....5a. C. elegans pallens.
        3. Capillitium arising along the entire length of the columella.
            4. Spores usually over 8 mu in diameter.
                5. Primary branches of capillitium stout and nearly straight.
                    6. Columella almost reaching the apex of the sporangium. ....6. C. laxa.
                    6. Columella usually branching well below the apex into 2 or 3 stout branches. ....6a. C. laxa rigida.
                5. Capillitium dense, composed of slender flexuose threads. ....7. C. nigra.
            4. Spores usually less than 8 mu in diameter.
                5. Spores marked with 3-7 large, prominent warts per hemisphere. ....8. C. typhoides.
                5. Spores more or less evenly warted or spinulose.
                    6. Capillitial threads below attached to the persistent base of the sporangium wall. ....9. C. rubens.
                    6. Sporangium wall not persisting at the base.
                        7. Capillitium dark purple-brown; spores pale brownish gray by transmitted light........10. C. subcaespitosa.
                        7. Capillitium paler.

8. Sporangia brownish or reddish brown.
   9. Capillitium a network of slender brown threads usually forming an imperfect surface net. ....11. C. pulchella.
   9. Capillitium a network of more rigid, purple-brown threads not usually forming a surface net. ....11a. C. pulchella fusca.
8. Sporangia reddish in color............12. C. tenerrima.

1. Comatricha longa Peck

Sporangia closely crowded, stalked, drooping, 7-14 mm in length, cylindrical, black. Sporangium wall evanescent. Stalk slender, black, shiny, 1-2 mm in length, arising from a more or less continuous, brownish, membranous hypothallus. Columella black, gradually tapering upwards almost to the apex of the sporangium, below often dividing into two equal branches. Capillitium an open network of sparingly branching and anastomosing, dusky brown threads with many outwardly pointed free ends. Spores nearly black in mass, brownish purple by transmitted light, globose, spinulose, the spines forming a close reticulation, 9.4-11 mu in diameter.

On bark of elm. Riley County.

2. Comatricha irregularis Rex

Total height 1.5-2 mm. Sporangia closely crowded, stalked, erect, cylindrical, dark purple-brown. Stalk slender, 0.5-0.8 mm in length, shining, nearly black above, reddish brown below. Hypothallus more or less continuous, reddish brown. Columella black, slender, gradually tapering upwards, zigzagging near the tip, reaching, or almost reaching the apex of the sporangium. Capillitium a lax network of purple-brown, branching and anastomosing threads forming an irregular surface net Spores dark purple-brown in mass, purple-brown by transmitted light, often paler on one side, globose, spinulose to nearly smooth, 8.3-9.5 mu in diameter.

On wood. Geary County.

3. Comatricha fimbriata G. Lister & Cran

Mr. Hagelstein (personal correspondence) reported that he found this species on a portion of TEB 374 along with *Macbrideola scintillans* Gilbert which developed in a moist chamber on elm bark collected in Geary County.

4. Comatricha cornea G. Lister & Cran

Sporangia scattered or solitary, stalked, globose, 0.05-0.15 mm in diameter, brown. Sporangium wall persistent as an irregular, brown, membranous collar at the base of the sporangium. Stalk 0.1-0.5 mm in length, slender, tapering upwards from a scanty, membranous hypothallus, corneous, yellowish brown at the base, becoming dark reddish brown above. Columella cylindrical, reaching half the height of the sporangium, dividing at the tip into several branches giving rise to the capillitium and often giving rise to a few scattered capillitial threads over the entire length. Capillitium scanty, of brown or pale threads branching sparingly. Spores brown in mass, lilaceous gray to lilaceous by transmitted light, globose, sparingly and irregularly warted, 7.8-10.6 mu in diameter.

Apparently common on bark of living deciduous trees. Although natural fruitings were not collected the species fruited abundantly on bark moistened and kept in a moist chamber. Geary County.

The stalk when treated with lactophenol is shown to be a smooth-walled tube. On the basis of this characteristic Hagelstein confirmed the writer's belief that these collections represent *Comatricha cornea* (2). Specimens, as yet, have not been sent to Miss G. Lister for verification. European specimens were described as 0.12-0.32 mm in diameter with stalks 0.17 to 0.2 mm high, and with spores gray in color (3). The young sporangia are white, becoming amber, then brown.

5. COMATRICHA ELEGANS LISTER

Sporangia gregarious, stalked, globose, 0.3-0.4 mm in diameter, purple-brown in color. Sporangium wall evanescent. Stalk slender, subulate, black, 0.5-0.7 mm in length. Hypothallus scanty. Columella soon dividing into stout branches which repeatedly subdivide giving rise to the dense, branching and anastomosing, purple-brown threads which form the capillitium. Spores purple-brown in mass, purplish brown by transmitted light, globose, minutely and closely spinulose, 9.4-11 mu in diameter.

On decaying wood. Geary County.

5a. COMATRICHA ELEGANS PALLENS G. LISTER

Sporangia subglobose, 0.2-0.4 mm in diameter, reddish lilac. Stalk slender, black, subulate, 2-2.5 mm in length, enclosed in a colorless membrane. Hypothallus imperceptible. Spores reddish violet in mass, pale reddish violet by transmitted light, minutely spinulose, 8 3-9.4 mu in diameter.

A single collection on twigs. Geary County.

6. COMATRICHA LAXA ROST.

Total height 0.3-1.5 mm. Sporangia scattered or gregarious in small clusters, stalked, globose, ovate, to short cylindrical, 0.3-0.4 mm in diameter, purple-brown. Sporangium wall membranous, evanescent, occasionally somewhat persistent. Stalk one third to two thirds the total height of sporangium, black, reddish brown at base, narrowing upwards. Hypothallus scanty, reddish brown. Columella black, tapering upwards, dissolving into the capillitium just below the apex of the sporangium, occasionally dividing into several branches near the tip. Capillitium lax or dense, purplish brown, with the primary branches straight or somewhat flexuose, arising at nearly right angles along the entire length of the columella, branching and anastomosing, often forming an imperfect surface net below, with free ends abundant above. Spores in mass purple-brown, purplish brown by transmitted light, globose, paler on one side, minutely warted, 8-11 mu in diameter.

Not uncommon on decaying wood and on the bark of living trees. Riley and Geary Counties.

Differing from *C. nigra* (Pers.) Schroeter in the comparatively shorter stalk, and in the capillitial threads arising from the columella at nearly right angles.

6a. COMATRICHA LAXA RIGIDA BRANDZA

Capillitium somewhat scanty or well developed, somewhat rigid. Columella usually dividing well below the apex of the sporangium into two or three stout branches.

A single collection on wood. Geary County.

7. COMATRICHA NIGRA (PERS.) SCHROETER

Sporangia gregarious to scattered, stalked, subglobose to short cylindrical,

0.2-0.3 mm in diameter, purple-brown. Stalk black, 0.3-0.6 mm in length, slender, tapering slightly from a scanty, colorless hypothallus. Columella black, reaching almost to the apex of the sporangium, above often dividing into two or three stout branches. Capillitium purple-brown, arising along the entire columella, branching and anastomosing to form a somewhat dense network of flexuose threads ending at the surface with free ends. Spores purple-brown in mass, purplish brown by transmitted light, globose, paler on one side, minutely warted, 9-11 mu in diameter.

Not uncommon on wood. Geary County.

8. COMATRICHA TYPHOIDES (BULL.) ROST.

Total height 1.0-3.5 mm. Sporangia gregarious to scattered, stalked, erect, cylindrical, 0.2-0.4 mm in diameter, 0.6-1.7 mm in length, silvery gray until dehiscence of the soon evanescent sporangium wall, then brown to purplish brown. Stalk reddish brown to nearly black, usually slender, enclosed in a silvery, membranous sheath, one third to two thirds the total height. Hypothallus well developed, reddish brown. Columella dark, slender, tapering upwards, dissolving into the capillitium below the tip of the sporangium. Capillitium springing from all parts of the columella, the primary branches rather stout, giving rise to a dense network of flexuose, brown threads which form a surface net below. Spores in mass brown, pale by transmitted light, globose, marked with 3-7 prominent warts per hemisphere, otherwise nearly smooth, 6-8.3 mu in diameter.

Common on decaying wood and grass. Riley, Douglas, Lyon, Harvey, and Geary Counties.

Mr. Hagelstein (personal correspondence) identified TEB 541 as the variety *similis* Lister because of the absence of the sporangium wall and the silvery sheath on the stalks. An examination of the available material of this species indicated that the sheath is almost indiscernible when closely attached to the stalk, but that it can almost always be seen, at least as a silvery, longitudinal streak.

9. COMATRICHA RUBENS LISTER

Sporangia gregarious to scattered, stalked, subglobose to ovoid, 0.2-0.4 mm in diameter. Sporangium wall evanescent above, membranous, brown, somewhat iridescent, persistent in the lower quarter of the sporangium. Stalk black, setaceous, 0.2-0.5 mm in length. Hypothallus scanty, membranous, reddish brown. Columella black, cylindrical, reaching about two thirds the height of the sporangium and branching at the apex. Capillitium composed of the purple-brown threads springing from all parts of the columella, usually expanded at the base, branching and anastomosing at wide angles, below attached to the persistent base of the sporangium wall. Spores lilaceous by transmitted light, globose, minutely roughened, about 7.2 mu in diameter.

On decaying leaves. Geary County.

The collection upon which this description is based was badly washed by rain and so the identification is somewhat doubtful. The spores of *C. rubens* in mass are typically pink-brown (4). In the above collection the spore mass is brown. Resembling *Lamproderma scintillans* (Berk. & Br.) Morgan, but differing in the capillitial threads dark at the base and springing from all parts of the columella.

10. COMATRICHA SUBCAESPITOSA PECK

Total height 1.5-2 mm. Sporangia gregarious, stalked, cylindrical, 0.2-0.3 mm in diameter, 1-1.5 mm in length, brown. Stalk slender, black, shining, 0.3-0.5 mm in length. Hypothallus scanty, dark. Columella black, tapering upwards, almost reaching the apex of the sporangium. Capillitium a network of flexuose, dark purple-brown threads. Spores in mass brown, pale brownish gray by transmitted light, globose, minutely warted, 6 7-7.8 mu in diameter.

On decaying wood. Geary County.

A single collection is placed here somewhat doubtfully. Closely allied to *C. typhoides,* but the spores are evenly warted and darker. *C. pulchella gracilis* Lister differs in the paler capillitium.

11. COMATRICHA PULCHELLA (BAB.) ROST.

Total height 0.4-1.2 mm. Sporangia gregarious in small clusters or scattered, stalked, globose, ovate to cylindrical, 0.2-0.4 mm in diameter, 0.2-1 mm in length, reddish brown. Stalk black, shining, nearly even, 0.1-0.4 mm in length, arising from a circular, reddish hypothallus. Columella black, shining, slender, extending nearly to the apex of the sporangium. Capillitium a network of slender, flexuose, brown threads, with free ends at the surface. Spores in mass reddish brown, pale violaceous brown by transmitted light, globose, minutely spinulose, 7-8.3 mu in diameter.

On fallen leaves. Geary County.

11a. COMATRICHA PULCHELLA FUSCA LISTER

Sporangia brown, cylindrical, stalked. Capillitium composed of more rigid, purple-brown threads with many free ends. Spores pale grayish brown by transmitted light.

On fallen leaves. Riley and Geary Counties.

12. COMATRICHA TENERRIMA (CURT.) G. LIST.

Sporangia narrowly cylindrical, short stalked, pale red. Capillitium a network of slender, flexuose, pale red threads forming an uneven surface net in the lower part of the sporangium. Spores pale violet-gray by transmitted light, globose, minutely spinulose, 7-8.3 mu in diameter.

On fallen leaves and grass stems. Geary County.

The collection described above is scanty and differs somewhat from typical *C. tenerrima.* Tentatively it is placed in this species because of the pale red sporangia and pale red, flexuose capillitial threads.

GENUS 13. ENERTHENEMA BOWMAN

Sporangia gregarious, stalked, globose. Sporangium wall evanescent. Columella entirely traversing the sporangium forming an expanded disc at the apex from which the sparingly branched capillitium originates.

1. ENERTHENEMA PAPILLATUM ROST.

Sporangia gregarious, stalked, globose, 0.3-0.6 mm in diameter, brown, tipped with a small, shiny, dark brown expansion of the columella. Sporangium wall evanescent except for a small brown collar at the base of the sporangium. Stalk stout, tapering upwards, equaling diameter of sporangium, black, shiny, slightly furrowed. Columella unbranched, somewhat cylindrical, slender, traversing the sporangium and expanding into a dark brown, cuplike disc. Capillitium abundant, radiating from beneath the expansion of the columella, consisting of long, simple or sparingly branched, brown,

flexuose threads. Spores brown, globose, minutely warted, 10-12 mu in diameter.

On decaying wood. Geary County.

GENUS 14. MACBRIDEOLA GILBERT

Sporangia scattered, stalked, globose to subglobose. Sporangium wall membraneous, colorless, persistent. Stalk setaceous, continuing into the sporangium as a columella entirely traversing the sporangium, or dividing above into a few simple branches.

1. MACBRIDEOLA SCINTILLANS GILBERT

Sporangia solitary, stalked, subglobose to slightly ovoid, 0.05-0.1 mm in diameter, shining. Sporangium wall membranous, fragil, colorless, shiny with depressed spots, falling away leaving a small brown collar at the base. Stalk slender, tapering upwards from a small, circular hypothallus, terete, brown. Columella a continuation of the stalk, concolorous, tapering, extending unbranched to the top of sporangium, or extending well into the sporangium, then branching dichotomously into a few simple threads. Spore mass brown, separated from sporangium wall leaving a free space. Spores violaceous by transmitted light, globose, minutely and irregularly spinulose, 8.5-11 mu in diameter.

Observed several times fruiting sparingly on elm bark cultured in moist chamber. Geary County.

Macbrideola differs from Lamproderma in the structure of the columella and capillitium. In Lamproderma the columella usually reaches to half or more the height of the sporangia and the capillitium consisting of branched anastomosing threads radiating chiefly from the upper part of columella. The columella of Macbrideola extends almost the height of the sporangium, and may remain unbranched or branch sparingly toward the top into a few short, simple threads.

GENUS 15. ECHINOSTELIUM DE BARY

Sporangia gregarious or scattered, stalked, globose, minute, white or pale. Sporangium wall persistent as a small collar at the base of the sporangium. Columella very short, giving rise to the scanty colorless capillitium. Spores colorless by transmitted light.

1. ECHINOSTELIUM MINUTUM DE BARY

Sporangia scattered, stalked, globose, 40-60 mu in diameter, nearly white in color. Stalk upright, 165-220 mu in length, slender, 9-11 mu in diameter at the base tapering to about 2 mu in diameter at the top, colorless but filled with nearly colorless granular matter except near the top, seated on a small circular hypothallus. Sporangium wall persistent as a small circular collar at the base of the sporangium. Columella colorless, slender, up to 25 mu long. Capillitium scanty, consisting of a few slender, colorless or pale, zigzag threads branching and anastomosing, with free hooklike branches. Spores in mass nearly white, colorless by transmitted light, faintly and minutely warted, 6-7 mu in diameter.

On pine bark collected in Geary County and cultured in a moist chamber. Probably common but usually overlooked because of its minute size.

GENUS 16. LAMPRODERMA ROST.

Sporangia gregarious or scattered, stalked, globose to subglobose, often brilliantly iridescent. Sporangium wall membranous, more or less persistent.

Stalk black, setaceous, continuing into the sporangium as a cylindrical or clavate columella which scarcely reaches the center. Capillitium abundant, originating from the tip of the columella.

1. LAMPRODERMA SCINTILLANS (BERK. & BR.) MORG.

Sporangia gregarious, stalked, erect, globose or subglobose, often somewhat umbilicate below, 0.2-0.4 mm in diameter, blue, violet, red, gold, bronze, or silvery, usually brilliantly iridescent. Sporangium wall membranous, thin, colorless or pale, often with a brown, more persistent base, falling away in large fragments. Stalk 0.1-1.7 mm in length, black, slender, setaceous, even or slightly tapering upwards from a small, circular, reddish brown hypothallus. Columella cylindrical, not reaching the center of the sporangium, black. Capillitium almost colorless at the base, composed of straight, rigid, purple-brown threads radiating from the tip of the columella, branching dichotomously and anastomosing near the extremities, often pale at the tips. Spores brown by transmitted light, globose, warted, 7.2-11 mu in diameter.

Very common on dead leaves. Geary, Riley, Edwards, and Saline Counties and Fort Riley Reservation.

GENUS 17. CLASTODERMA BLYTT

Sporangia gregarious or scattered, stalked, subglobose, Sporangium wall persistent as fragments adhering to the tips of the capillitial threads.

1. CLASTODERMA DEBARYANUM BLYTT

Sporangia scattered, stalked, subglobose, 0.1-0.2 mm in diameter, copper-red. Sporangium wall evanescent except for the small, irregular, shiny patches adhering to the tips of the capillitial threads and a small collar at the base of the sporangium. Stalk long, tapering from a scanty hypothallus, often unequal, somewhat furrowed, dark brown below, paler above. Columella very short, dividing into comparatively few, primary capillitial branches. Capillitium consisting of slender, brown threads which branch several times, the ultimate branches of which are attached to the persistent patches of sporangium wall. Spores in mass copper-red, nearly colorless by transmitted light, globose, minutely spinulose, about 8 mu in diameter.

This species developed on bark collected in Geary County, and kept in moist chambers.

The spores of this species are described by Lister (3) as pale brown and smooth, and by Macbride and Martin (4) as violaceous and even. In the collections described above the spores are nearly colorless when mounted either in water or 3 percent KOH, and are minutely but distinctly spinulose. The stalks are uneven, but do not show the swollen portion about two-thirds of the way up from the base as noted by some writers. As many as six or seven of the ultimate branches of the capillitium may be attached to the same persistent patch of the sporangium wall.

LITERATURE CITED

1. BROOKS, TRAVIS E. Myxomycetes of Kansas—I. Trans. Kans. Acad. Sci. 44:130-157. 1941.
2. HAGELSTEIN, ROBERT. Notes on the Mycetozoa—V. Mycologia. 33:294-309. 1941.
3. LISTER, ARTHUR. A Monograph of the Mycetozoa. 3rd. ed. revised by Gulielma Lister. England. Oxford University Press. 296 p. 1925.
4. MACBRIDE, T. H., and MARTIN, G. W. The Myxomycetes. New York. Macmillan. 339 p. 1934.

7

Estimating the Yield of Blue Grama Grass Seed

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INTRODUCTION

The wide adaptation of blue grama, *Bouteloua gracilis,* to different soil and climatic conditions of the western part of the Great Plains has made it one of the most important native grasses for revegetation plantings. Blue grama is used as the base grass for most native grass mixtures planted in the Southern Great Plains west of the 98th meridian For such plantings a large amount of seed must be harvested each year. During the season of 1941, approximately 300,000 pounds of blue grama grass seed was harvested in Wallace County, Kansas.

It would be valuable for seed collectors and farmers to have a method of estimating the yield of blue grama grass seed by an inspection of the range before the actual harvest begins. Such a method would make it possible to estimate the value of the unharvested crop and tell the number of acres necessary to give the pounds of seed desired, the amount of equipment and storage space needed, and a basis for testing the efficiency of the harvesting machinery.

Considerable work has been done in estimating the carrying capacity of western ranges to afford a basis for proper stocking. Although these studies concern forage production rather than seed production, they afford a knowledge of the variability of the native prairie and give some methods that might be applicable in estimating seed production.

REVIEW OF LITERATURE

Modifications of the quadrat method of Clements (Weaver and Clements 6) have been used to good advantage by several investigators. In a native prairie of western North Dakota, Hanson (3) compared several methods of botanical analysis using a wooden sampling frame 8 dm. long and 5 dm. wide or 0.4 m^2.

Davies (1) divided one-half acre of natural grassland in Australia into 1000 plots. The forage yields were determined for the plots and statistical analysis gave a standard error in pasture at least double that obtained in wheat, mangolds, and sorghum. Davies also tried long plots and found the percentage error to be reduced, possibly by the fact that a long narrow plot must necessarily cross a larger number of "societies" than a square plot of equal area; societies tend to exist in circles of varying, but generally limited, diameters.

Wood and Stratton (7) did not find any distinct difference in the probable error for different crops, except in the case of seed production of hay-grasses where the error was greater than for field crops.

Hanson, Love, and Morris (2) used the number of seed stalks for 30 quadrats, two meters square, per pasture in comparing two different systems of grazing.

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Pechanec and Stewart (4) found variability in forage yield of individual species of native vegetation in sagebrush-grass range harvested as 5 by 5 foot units to be greater than 30% of the mean, or 2 to 3 times that encountered in experiments on cultivated land.

RESULTS

Three fields of blue grama, each about forty acres in size, were sampled in Wallace County, Kansas, in early August, 1941. All of the fields were typical of the short grass plains *Bouteloua-Buchloe* association. Field A was relatively level with some water coming from adjacent slopes. Field B was slightly sloping (about a two percent slope). Field C had steeper slopes of about five percent. Fourteen quadrats, each one meter square, were sampled in each of the three fields. The location of the quadrats within each field was determined by throwing one quadrat iron to give random distribution.

The following data were obtained from each quadrat: percent basal cover of blue grama, buffalo grass, and weeds; height of seed stalks; number of seed stalks; and yield of seed in grams. The yield of seed in grams per square meter-quadrat was later converted to pounds per acre.

The number of flags per seed stalk was determined for 100 seed stalks from each of ten different quadrats. There was an average of 1.77 spikes per seed stalk. The number of florets per spike was determined for ten spikes and averaged 49.4 florets per spike. Four caryopsis counts were made for each field, the average of the four being as follows: A, 35.9%; B. 35.8%; and C, 24.3%. The seed material from the quadrats was bulked together. This material was obtained by stripping the spikes from the seed stalks; it had a purity of 36.2% seed and 63.8% inert material, consisting of empty florets, broken stems, etc. The seed material had 238,804 seed per pound or 657,165 seed per pound on a pure seed basis.

A high correlation between the number of seed stalks and yield was found to exist. A determination of the number of seed stalks per meter X and conversion to yield per acre E by use of the regression coëfficient $E=0.40825X + 7.866$, Figure 1, would give a good estimate of yield if sufficient quadrats are sampled. Although the number of spikes per seed stalk and the number of florets per spike would probably not vary much from the results reported herein, they could be easily determined for any field to be harvested.

One of the most variable factors and of greatest importance to the seed collector is the caryopsis count or percentage of florets containing caryopses. This count should always be determined before a harvest is started. Frequently hot dry winds or insufficient soil moisture at flowering time will prevent good seed production. If the caryopsis count of a field to be harvested is higher than reported here, although the count of seed stalks may be comparable, the yield of pure seed per acre will be accordingly higher; a lower caryopsis count would give lower purity and lower yield of pure seed per acre.

Although the fields appeared to be uniform from a short distance, it was found on close observation within the fields that there was great variation in the amount of seed being produced by small local areas. This variation is shown by the graph in Figure 1 and by the high standard deviations from the means given in Table 1. As a result of the great experimental error involved,

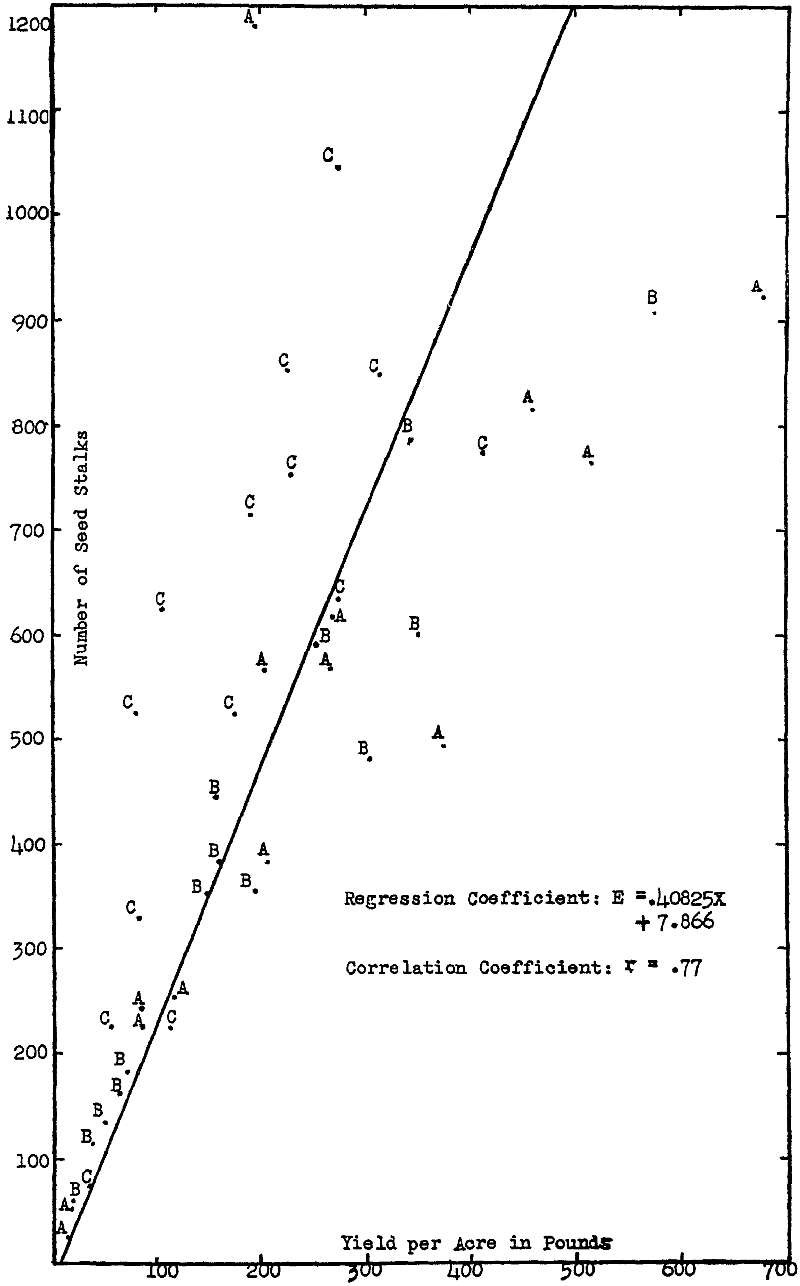

FIGURE 1. Regression of number of seed stalks per meter on yield of blue grama grass seed (basis of lbs. per acre). A, B, or C designates field from which quadrat sample was obtained.

it would require many meter quadrats (from 200 to 300) to obtain an estimate within 10% of the mean yield at the 95% level of probability, Table 1. If some method of reducing the error such as using long narrow plots as suggested by Davies (1) could be used in place of meter quadrats then fewer plots would be required.

TABLE I—Size of sample required in sampling native blue grama ranges for seed production estimates to fix fiducial limits at 10% from sample mean, 95% level of probability.

Field Designation	Yield of seed, lbs. per acre* Mean	Standard Deviation	No. samples needed**	Seed stalks per square meter Mean	Standard Deviation
A	253	189	262	509	334
B	195	121	302	397	259
C	184	111	170	583	226

*Calculated from grams per quadrat.

**Determined by use of formula $n=t^2V/1^2$ in which for 13 degrees of freedom $t_{.05}=2.16$, V=standard deviation squared, 1=10% times mean. (Snedecer's (5) Statistical Methods, p. 391).

SUMMARY AND DISCUSSION

Fourteen meter-quadrat samples in each of three fields were taken to determine the possibility of estimating blue grama grass seed yields. A high correlation of number of seed stalks to yield of seed was found to exist. The regression coefficient E=0.40825X + 7.866 may be used to convert number of seed stalks per square meter X to yield of seed per acre E in pounds. A high standard deviation necessitates the sampling of many quadrats for the estimate to come within 10% of the mean with a probability of 95%.

The data presented here may be regarded as a progress report in an effort to determine practical methods in estimating yields of seed. The method used requires too many separate counts to make rapid determinations possible. The amount and nature of variability of seed areas would indicate that some method could be devised to estimate yields; these data are presented with the hope that they will lead to further work in this field.

LITERATURE CITED

1. DAVIES, J. GRIFFITH. The experimental error of the yield from small plots of "natural" pasture. Australian Council Sci. and Ind. Res. Bul. 48. 1931.
2. HANSON, H. C., L. D. LOVE, and M. S. MORRIS. Effects of different systems of grazing by cattle upon a western wheat-grass type of range. Colo. Agric. Exp. Sta. Bul. 377. 1931.
3. HANSON, H. C. A comparison of methods of botanical analysis of the native prairie in western North Dakota. Jour. Agric. Res. 49:815-842. 1934.
4. PECHANEC, J. F. and STEWART, GEORGE. Sagebrush-grass range sampling studies: variability of native vegetation and sampling error. Journ. of Am. Soc. of Agron. 33:1057-1072. 1941.
5. SNEDECOR, GEORGE W. Statistical Methods. Iowa State College Press, 1940.
6. WEAVER, J. E. and CLEMENTS, F. E. Plant Ecology. p. 11. McGraw-Hill, New York, 1938.
7. WOOD, T. B. and STRATTON, F. J. M. The interpretation of experimental results. Journ. Agric. Res. 3:417-440. 1910.

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The Effect of Different Intensities and Times of Grazing and the Degree of Dusting Upon the Vegetation of Range Land in West Central Kansas

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INTRODUCTION

Variations in the total environment of range land have produced vastly different results in both composition and basal ground cover of the native vegetation. The purpose of this study was to determine the effects of different intensities and dates of grazing, and different degrees of dusting from adjacent cultivated fields upon the composition and cover of the native range. A need for information on grazing intensities and their effect on the vegetation has been recognized. This need for data on intensities of grazing for this part of the state is especially evident to those whose duty it is to recommend the practices for range and pasture improvement.

RELATED STUDIES

The effect of different intensities of grazing upon the native vegetation has been studied by Sarvis (1923) in North Dakota. Black, Baker, Clark, and Mathews (1937) have done similar work in South Dakota. Comprehensive ecological studies of central Kansas have previously been made. Weaver and Clements (1938) described the nature and extent of the mixed prairie and the short grass disclimax. Albertson (1937) gave a detailed description of the structure of the types and their distribution and the reasons for their distribution in the mixed prairie of Kansas. Shantz (1923) gave a detailed description of the plains west of the mixed prairie Savage and Jacobson

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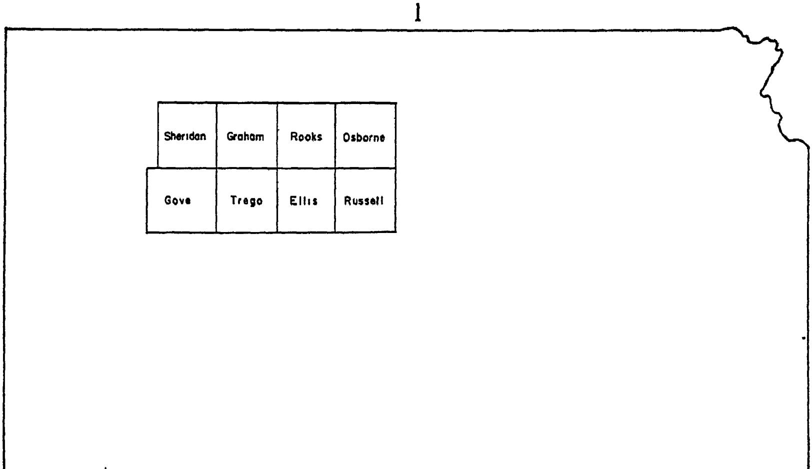


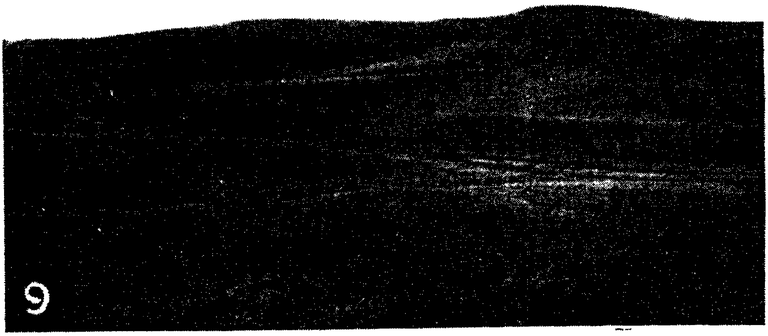
FIGURE 1. Map of Kansas showing the region where the study was made.

Transactions Kansas Academy of Science, Vol. 45, 1942.

FIGURE 9. A general view of Russell county pasture showing the topography of the land.

FIGURE 10. A general view of a Sheridan county pasture showing the topography of the land.

FIGURE 11. A view of two pastures in central Kansas. The pasture in the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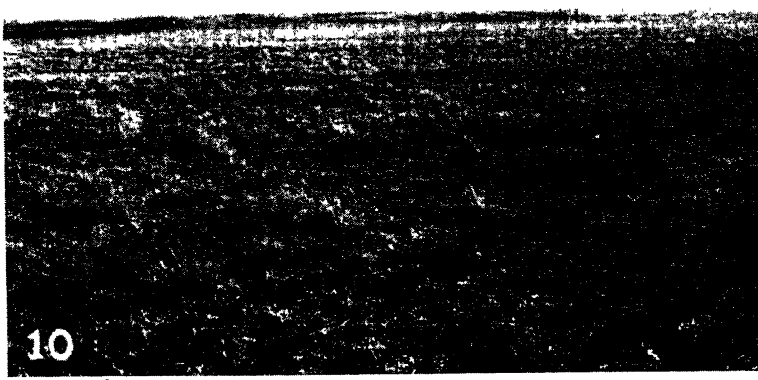
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(1935) studied the effect of heat and drought upon buffalo and blue grama grass under different intensities of grazing. Indicators of southwestern range conditions have been suggested by Talbot (1937). Some of these indicators can also be applied to Kansas ranges.

NATURAL CONDITIONS OF AREA STUDIED

West-central Kansas is here used as that part of the state west of and including Russell County and extending west to and including Gove and Sheridan Counties. The area is two counties wide and includes Rooks and Ellis Counties. This makes the region approximately seventy-five miles wide and one hundred twenty miles long (Fig. 1).

The general topography of the region is rolling to gently rolling (Fig. 9). The land adjacent to rivers and creeks is broken by ravines, making it too rough for cultivation. The upland and land several miles away from the main creeks and draws is level to rolling and it, together with a narrow band on the river bottom, is used for cultivation. From 33 to 41 percent of the land remains in native pasture. The topography characterized by level upland with sharp breaks to the low lands, is limited largely to the region east of the 100th meridian. That region west of the 100th meridian is characterized by more level, rolling country with gentle slopes to the river and creek beds (Fig. 10).

The soils of central Kansas are composed of the Hays series and associated soils (Soils and Men, 1938). In most places the soils are developed over shales and limestone of the Cretaceous age. An outcrop of the Dakota sandstone is found on the eastern boundary of Russell County. Westward in the county is found the Benton limestone, and then farther west in Ellis County the Fort Hays limestone outcrops.

The soils of the western part of the region are of the Holdrege series on the uplands and the Hall series on the terraces. Peorian loess covers all the area except narrow strips along some of the valley slopes where Pleistocene sands or calcareous Teritiary rocks are exposed.

The area of study is located in that region which receives 25 inches or less of precipitation per year. The normal annual precipitation at Hays, Kansas, is 23.69 inches for a 71-year period. Table I gives the normal, annual, and seasonal distribution of precipitation at six stations for the years 1930 to 1939, inclusive.* It should be noted that the normal annual rainfall progressively decreases in amount from Russell, (Russell County), the east-most station, to Hoxie, (Sheridan County), the west-most station, with the exception of that of Quinter (Gove County). This exception can be accounted for by the fact that the record for Quinter is only 13 years old which, judging from other stations, should include as many as 5 to 9 years of rainfall below normal. The average annual rainfall received during the 10-year period also progressively decreases from east to west if the .20 of an inch between Hays and Russell is disregarded.

*Flora, S. D. Climatological Data—Kansas Section. U.S.D.A., Weather Bureau. Topeka, Kansas. (Record from 1930 to 1939 inclusive.)

TABLE I—Precipitation at six stations in west-central Kansas, 1930-1939

Stations	Monthly average in inches April	May	June	July	Aug.	Sept.	Average annual, inches	Normal annual, inches	Departure from normal ins.
Russell	1.83	3.19	3.02	1.56	2.88	2.72	20.67	25.32	—4.65
Hays	1.57	3.50	3.91	1.55	3 01	2.32	20 87	23.69	—2.82
Phillipsburg	1.86	2.56	2.74	2.24	2.84	2.35	19.51	23.27	—3.76
Wakeeney	1.68	3.81	3.81	2.04	2.34	2.08	19.67	22.14	—2.47
Quinter	1.60	3.15	3.26	1.60	2.19	2.14	18.25	17.56	+.69
Hoxie	1.63	3.16	2.54	1.53	2.02	1.29	16.87	20.11	—3.24

Only during the months of August and September does the monthly precipitation at the different stations increase progressively from west to east.

The distribution during the growing season is fairly consistent. The months of heaviest rainfall are May and June; those of intermediate rainfall are August and September, and the months of lightest rainfall are April and July. An exception, however, is shown at the Phillipsburg (Phillips County) station where there was a very even distribution throughout the season. By personal observation, it is known that rainfall at points only a few miles apart varies considerably. Therefore, it is not considered that vegetation on the areas selected for this study have received exactly the amount of rainfall recorded for the station nearest the area.

The typical vegetation of the eastern counties is known as the mixed-prairie. This is the region where the tall grass of the true prairie gives way to the short grasses. Three types of vegetation have developed here because of the different soil and moisture relations (Albertson, 1937).

The big bluestem habitat is in the low land along the streams and in the bottom of ravines or draws. Runoff from upland and drifted snow as well as protection from drying winds makes this habitat more mesic than the others. The dominant grasses are: big bluestem (*Andropogon furcatus*), western wheatgrass, (*Agropyron smithii*), side-oats grama (*Bouteloua curtipendula*), and *Sporobolus asper var. Hookeri.* Grasses of lesser importance are *Elymus canadensis, E. virginicus, Panicum virgatum, Andropogon torreyanus,* blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), *Sporobolus asper,* and *S. cryptandrus.* The principal forbs are: *Amorpha canescens, Aster multiflorus, Erigeron ramosus, Psoralea tenuiflora, Salvia pitcheri, Verbena stricta,* and *Veronia baldwini.*

The little-bluestem habitat is limited to the hillsides and shallow ravines, and extends over the brow of the hills, but gives way more or less abruptly to short grasses. This habitat is dominated by little-bluestem (*Andropogon scoparius*). Associated with little-bluestem are scattered plants or clumps of *Andropogon furcatus, Bouteloua curtipendula, B. gracilis, B. hirsuta, Panicum virgatum, Sitanion hystrix, Sorghastrum nutans,* and *Sporobolus pilosus.* Forbs likely to be well developed here are: *Amorpha canescens, Echinacea angustifalia,* and *Tetraneuris stenophylla.* Other species characteristic of the habitat are *Psoralea tenuiflora, Viorna fremontii, Liatris punctata, Tithymalus arkansanus, Cheirinia asper, Meriolix serrulata* and *Spermolepis patens.*

The short grass habitat is limited to the upland. The two short grasses, buffalo grass and blue grama, comprise most of the vegetation. Triple-awn grass (*Aristida purpurea*) appears occasionally. Other important species are: little-bluestem, side-oats grama, and *Sitanion hystrix.* These mid-grasses are not abundant but are conspicuous as are also bunches of cacti (*Opuntia humifusa*), and societies of golden-rod (*Solidago mollis*), *Malvastrum cocci-*

neum, and *Psoralea tenuiflora.* Low growing forbs which are usually conspicuous are *Leucelene ericoides, Diaperia prolifera, Oxalis stricta, Draba caroliniana, Astragalus shortianus,* and *Hedeoma hispida. Guiterrezia sarothrae* and *Liatris puntata* are taller species that are common to abundant.

EXPERIMENTAL PROCEDURE

Grazing records of all the areas were obtained from the operators. The number and kind of livestock and the length of the season in months were obtained so that the grazing load could be made in animal units. One grown cow on an area for one month constituted one animal-month. Twelve animal-months were required per animal unit. The number of acres of each area was also obtained. Dividing the number of acres by the animal units the area supported in a year, gave the acres per animal unit per year.

Representative plots, one meter square, were located on each area. The vegetation on these plots was charted and transferred to paper by means

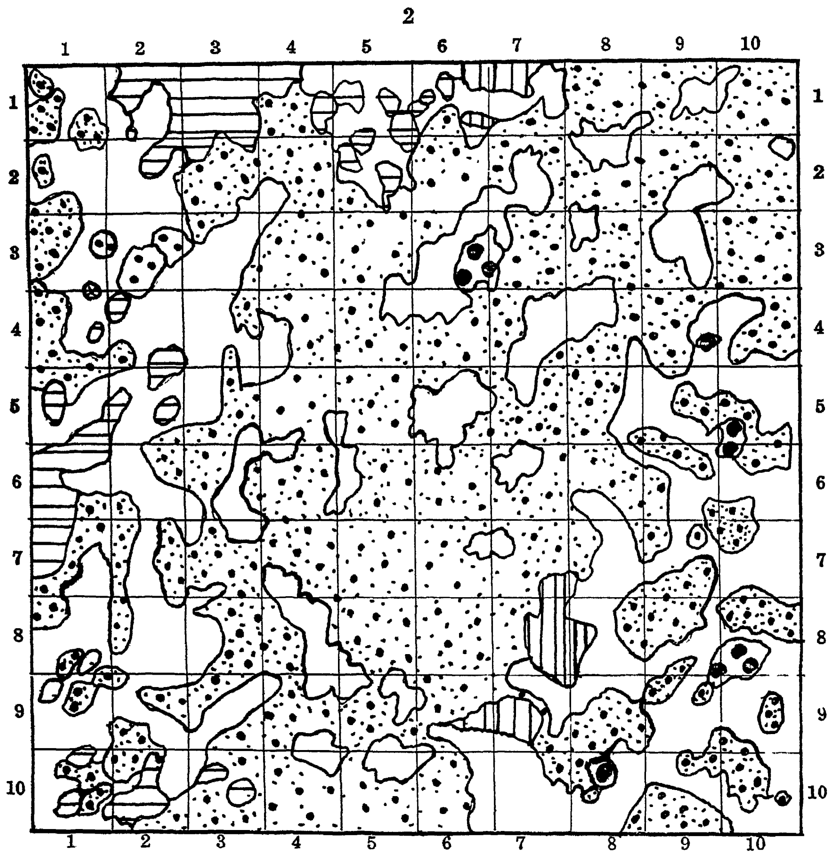

FIGURE 2. Meter quadrat from a l'ghtly grazed pasture. Total cover 57.8 percent. Most of the grass was short grass (medium and small dots). Small amounts of side-oats grama (vertical hatch), big bluestem (horizontal hatch), and sand dropseed (large dots) were present.

of a pantograph made for that purpose. A planimeter was used to determine the percentage of ground cover of each species of grass. Forbs were located on the charts, but were not included in the ground cover. Other items were noted such as degree of utilization, amount of dusting, and relative abundance of cactus. Pictures were taken of the representative plots as well as some general views of the pastures.

RESULTS

The pastures were grouped according to the degree of use each had received. The most heavily grazed pastures in the same part of the region in each case were found to have the lowest basal ground cover. The pastures in the eastern part of the region were found to be grazed at a heavier rate than those in the western part and still held a heavier vegetative cover. This behavior correlates with the heavier rainfall in eastern counties.

In comparing the basal ground cover of hillside plots between heavily grazed and lightly grazed pastures, there was found to be little difference. Usually a better top growth and better flower production was found on pastures not heavily grazed.

Since hillside plots showed no significant differences the remainder of the discussion is confined to upland and bottom land plots. In all cases the principal cover consisted of short grasses.

Table II shows the basal ground cover of plots in the short-grass habitat and the past use in acres per animal unit on heavily grazed pastures in central Kansas. The average rate of use was 15.1 acres per animal unit. The average basal ground cover was 21.5 percent. Some of the better pastures, such as numbers 31 and 13, had a cover which was very similar to that of moderately grazed western Kansas land. The vegetation on these pastures was very short. No reserve foliage was present as is recommended for good range practice. Side-oats grama was limited to the hillsides. Little-bluestem was frequently found here also. The short grasses were the dominant grasses. Typical ground cover is shown in Figure 3.

TABLE II—Basal ground cover in short-grass habitat and past use of heavily grazed pastures in central Kansas, 1939.

Pasture number	Pasture use—acres per animal unit	Percent basal ground cover
11	15.4	
12	13.3	
13		25.32
14	16 5	23.10
15	16.7	17.50
16	14.0	16.94
31		24.71
Average	15.1	21.51

TABLE III—Basal ground cover in the short-grass habitat and past use on moderately grazed pastures in central Kansas, 1939.

Pasture number	Pasture use—acres per animal unit	Percent basal ground cover
3a	16.4	32.92
4	17.9	31.19
5	18 0	30.70
7	20.9	28.84
8	26.2	27.28
10	26.0	34.82
Average	20.9	30.95

The treatment and condition of moderately grazed pastures are shown in Table III. The average rate of past use was 20.9 acres per animal unit.

FIGURE 3. Typical cover of a heavily grazed pasture in central Kansas. All of the 21.9 percent cover was of short grasses except a small amount of sand dropseed (large dots).

FIGURE 4. Meter quadrat, typical of the short-grass cover under moderate grazing in central Kansas. The cover of 32.9 percent was composed entirely of short grass.

FIGURE 5. Typical lightly grazed area in central Kansas. Buffalo grass and blue grama grass (medium and small dots) form most of the cover. Sand dropseed (large dots) constituted only a small portion of the total cover of 59.9 percent.

FIGURE 6. Typical meter quadrat in heavily grazed pasture in central Kansas shown in Figure 7. The open cover of 43 percent caused by drought and over-grazing is mostly short grasses. Sand dropseed (large dots) constitutes the remainder of the cover.

FIGURE 7. This meter square area is representative of the condition in western Kansas under heavy grazing. The cover was reduced to 17.3 percent, most of which was short grass. Less than 1 percent was sand dropseed (large dots).

FIGURE 8. Meter quadrat showing typical basal cover in moderately grazed pasture in western Kansas. Buffalo grass and blue grama grass (medium and small dots) comprise most of the cover. Sand dropseed (large dots) often invades the open places. Total cover 28.4 per cent.
foreground was grazed at the rate of 13.3 acres per animal unit while the one in the background was grazed at the rate of 68 acres per animal unit.

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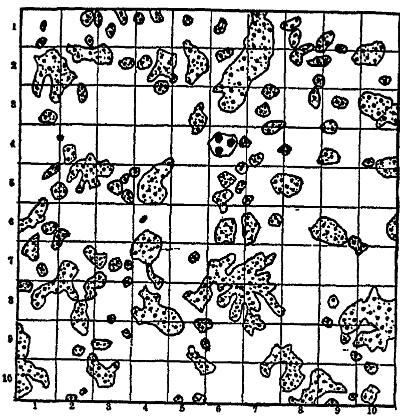

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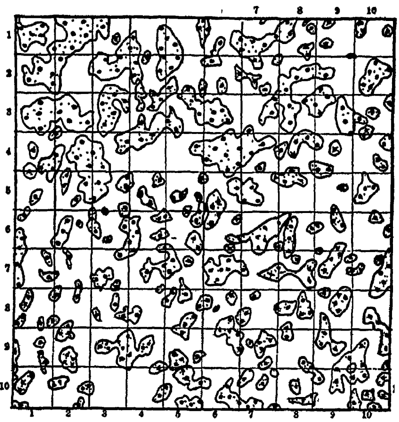

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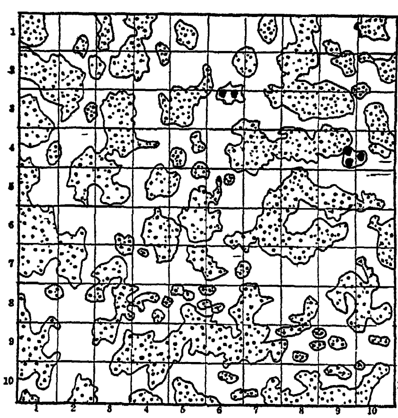

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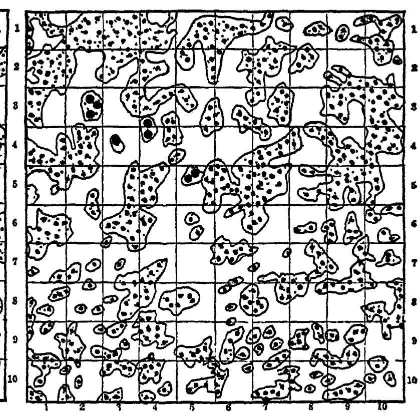

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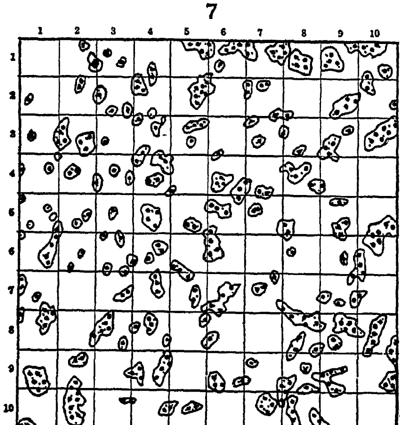

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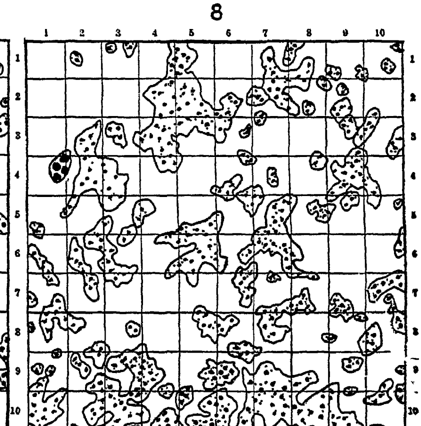
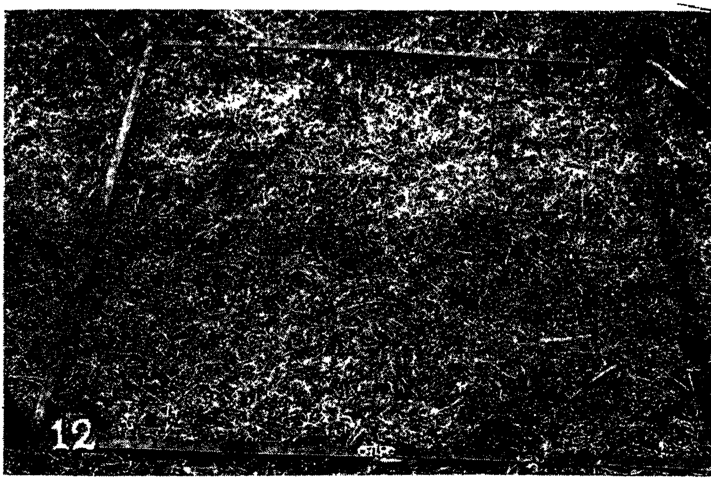


FIGURE 12. View of the plot represented by the chart in Figure 8. Note the absence of reserve foliage or protective cover.

FIGURE 13. A gully approximately six feet deep which is the result of excessive runoff in central Kansas.

FIGURE 14. A view of the plot represented by the chart in Figure 2. Note the good foliage cover and the presence of the tall grasses.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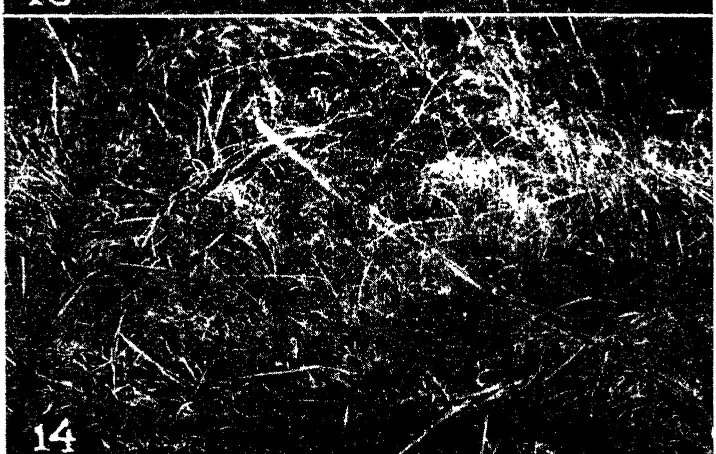
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The average basal ground cover was 30.9 percent. The pasture receiving the hardest use was 3a, having been grazed at the rate of 16.4 acres per animal unit. This degree of grazing was no heavier than some of the areas in the heavily grazed classification, but because of the method of rotation it had been able to withstand the grazing. The typical ground cover of a moderately grazed plot is shown in Figure 4.

The past use and the condition of a lightly grazed pasture in central Kansas are shown in Table IV. The average past use in acres per animal unit for the period of five years is 45.8. The grazing load on these pastures was less than one-half of that on the moderately grazed units. The average per cent of basal ground cover showed a distinct gain in being about twice that of moderately grazed areas and about three times that of heavily grazed areas. Pasture number 3, a winter grazed area, did not show as great a gain as did that of the summer grazed. Typical ground cover is shown in Figure 5.

TABLE IV—Basal ground cover in the short-grass habitat and past use of lightly grazed pastures in central Kansas, 1939.

Pasture number	Pasture use—acres per animal unit**	Percent basal ground cover
1	68	36.52
2	45.7	77.00
3	*	35.70
4	23.7	86.90
Average	45.8	59 03

*Winter pasture
**Average—1934-1939 inclusive.

A typical view of heavily grazed and lightly grazed pastures is shown in Figure 11. The area in the foreground and to the right of the fence had been grazed at the rate of 13.3 acres per animal unit. The area in the background and left of the fence had been grazed at the rate of 68 acres per animal unit. Plots were established to show the typical vegetative cover of these two pastures. Each was located in the same habitat so as to show the result from the difference in grazing. Basal ground cover under heavy grazing is shown in Figure 6. The total ground cover was 41.9. It will be noticed that the plot is principally short grass with a trace of sand drop-seed (*Sporobolus cryptandrus*). Side-oats grama was found only on the hillsides. Only traces of big bluestem could be found. *Gutierrezia sarothrae* was conspicuous on the rough breaks and slopes. Utilization of the area was complete as is shown by the photograph (Fig. 12). This left little protection to the ground and run-off was rapid. Drainage from this pasture together with that from a small cultivated area had created a gully approximately 6 feet deep (Fig. 13).

The chart (Fig. 2) representing the lightly grazed pasture shows a basal ground cover of 57.7 per cent. This cover includes 3.9 per cent big bluestem and 1.7 per cent side-oats grama, both of which were absent from the plot in the adjoining pasture. This plot also had a trace of *Sporobolus asper var. Hookeri*. In the immediate area were found *Panicum virgatum* and *Elymus canadensis*. Two common forbs, *Aster multiflorus* and *Verbena bipinnatifida,* were also present. *Gutierrezia sarothrae* was present but was not conspicuous. An ample top growth remained on the ground which protected it from washing (Fig. 14). There was no evidence of excessive water erosion on this area.

The basal ground cover and past use of some pastures near the Rooks County line south of Phillipsburg, Kansas, is shown in Table V.

TABLE V—Basal ground cover and past use of pastures near Phillipsburg, Kansas, 1939.

Pasture number	Pasture use—acres per animal unit	Percent basal ground cover
19	hay meadow	57.55
18	13.1	48.75
17	4.2	25.60

The heavily grazed pasture was used at the rate of about 4.2 acres per animal unit and had a basal ground cover of 25.6 percent. The area was almost a pure short grass type. Utilization was complete, including any palatable forbs. No top growth remained.

Pasture number 18 adjoined the above area but had been grazed at the rate of 13.1 acres per animal unit. Basal ground cover of this area was 48.7 percent. This was almost twice as much as the above mentioned pasture. Considerable top growth remained and prevented water run-off.

Adjoining the two above mentioned pastures was an area which had been used as a hay meadow for a number of years. A plot established there showed a basal ground cover of 57.5 percent. This is an increase of about 9 percent over that of the moderately grazed pasture. An excellent top growth was present before the hay was cut and sufficient cover remained in the aftermath which prevented any serious erosion. Both the moderately grazed pasture and the hay meadow showed numerous traces of side-oats grama, and a few traces of big bluestem and little bluestem.

The results of the studies on the pastures in western Kansas are shown in Table VI. Heavily grazed pastures were used at the rate of about 8.5 acres per animal unit. The average basal ground cover on these was 14.9 percent. A typical plot is shown in Figure 7 and a photograph showing the top growth is shown in Figure 14. The grass in these pastures had been grazed very closely leaving no top growth for protection and reserve. In general there was a good distribution of plants over the ground. Bunches of cacti (*Opuntia humifusa*) were frequent. Relics of *Hordeum pusillum* and *Lepidium densiflorum* were frequent to abundant.

TABLE VI—Basal cover of grasses and their past use in Western Kansas, 1939.

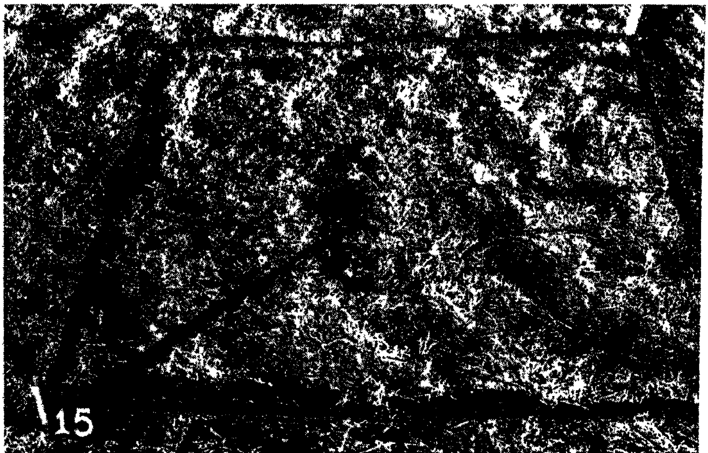
		Pasture number	Pasture use—acres per animal unit	Percent basal ground cover
Grazed	Heavily	20	9.8	18.70
		21	9.9	17.34
		28	6 6	8.94
		Average	8.5	14.99
	Moderately	25	22.2	28 42
		29	21.0	32.90
		24	17.1	22.20
		Average	20.1	26.63

Moderately grazed pastures were grazed at the rate of about 20.1 acres per animal unit. The average basal ground cover for this group was 26.6 percent. A typical plot (Fig. 8) shows a more bunchy but heavier type of cover. Some flower stalks and reserve foliage were allowed to remain at this intensity of grazing (Fig. 10). Cacti were also numerous here. Many relics of *Lepidium densiflorum* and *Hordeum pusillum* were also present in the spaces between clumps of grass.

FIGURE 15. A view of the plot represented by the chart in Figure 7. This is the typical appearance of heavily grazed pastures in western Kansas.

FIGURE 16. A view of a typical plot of a moderately grazed pasture in western Kansas showing the foliage for reserve.

FIGURE 17. A view showing the results of extreme dusting on a pasture in western Kansas. The vegetation in the foreground is principally Russian thistles. Some western wheat-grass can be seen in the background.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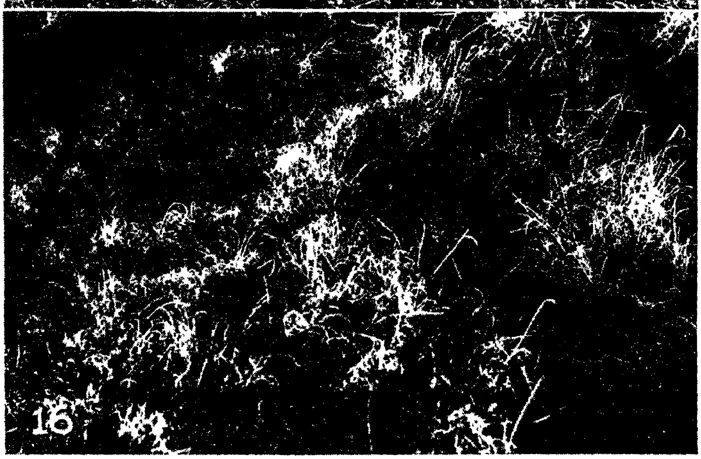
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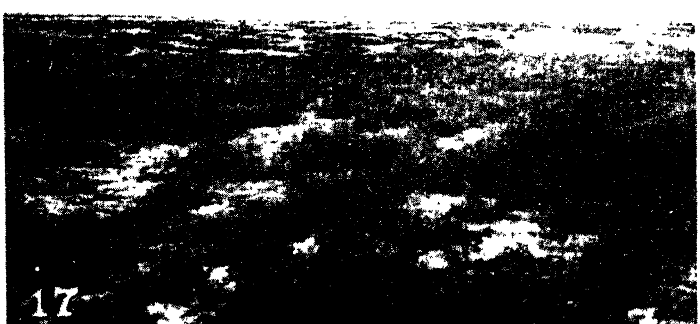
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TABLE VII—Ground cover of grass and past use of lightly used pastures in western Kansas, 1939.

	Pasture number	Pasture use—acres per animal unit	Percent basal ground cover
	26	25	30.70
	23	187	30.90
	22	31	37.50
Average		81	33.03

The results from lightly grazed pastures in western Kansas is shown in Table VII. The average basal ground cover of grasses was about 33.0 percent. There was a range between 25 and 187 acres per animal unit for the grazing load. Pasture number 23 had been pastured very lightly during the last five years in order to aid its recovery. It showed a good top growth and some stalks of blue grama (Fig. 16). Cacti were present but not numerous.

In a number of the pastures large areas of ground had had their grass cover eliminated or materially reduced by drought and dusting. Russian thistle (*Salsola pestifer*) was the chief plant in revegetating these areas. An extreme case is shown in Figure 17. Practically the only grass remaining was a society of western wheatgrass (*Agropyron smithii*) which shows up in the background.

SUMMARY

This study was made to determine the effect of a number of different kinds of treatment upon the native vegetation of central and western Kansas. The different intensities of grazing were the most significant. That, with the different rainfall for the different parts of the region, produced a definite vegetative cover.

Pastures in central Kansas where the average rainfall was about 20 inches annually were considered to be too heavily grazed if the rate was about 15 acres per animal unit. This degree of use resulted in a basal ground cover of grasses of about 21.5 percent. Utilization of the foliage was complete so that there was no protection from water erosion nor opportunity for reproduction by natural reseeding. The vegetation consisted principally of the two short grasses, buffalo grass and blue grama grass, and took on the typical short grass appearance except on the steep slopes *Gutierrezia sarothrae* was found frequently.

Central Kansas pastures were considered to have been moderately grazed if the rate had been about 20 acres per animal unit. The basal ground cover of grasses was about 31 percent. This was about 10 percent better than pastures grazed at the rate of 15 acres per animal unit. Moderate grazing did not utilize the foliage to the extent that it exposed the ground to washing and allowed some for reserve and reseeding. Pasturing lighter than 26 acres per animal unit definitely gave the vegetation a chance to improve both in basal cover and in type of plants.

The basal ground cover on the hillsides in central Kansas was approximately the same on all types of grazing. Side-oats grama and little bluestem were largely limited to the hillsides. This was no doubt due to the drought as Albertson reports these mid-grasses extending up over the brows of the hills.

The pastures near the Rooks County line south of Phillipsburg had a better cover of grasses according to the past use than those in Russell and Ellis Counties. Grazing at the rate of 13.1 acres per animal unit resulted

in a basal ground cover of 48.7 percent or similar to that of some lightly grazed areas. It is considered that the better condition of the grass in this locality was due to more favorable weather conditions. Reduction of the grazing load showed a definite increase in basal ground cover as the moderately grazed pasture and the hay meadow both showed almost twice the cover as that of the heavily grazed pasture.

Pastures in western Kansas where the average rainfall was less than 19 inches were considered heavily grazed if they had ben used at a rate heavier than 17 acres per animal unit. The basal ground cover of these pastures averaged less than 15 per cent. Ground cover this low and completely utilized offered very little resistance to water erosion. Recovery by natural reseeding was prohibited but the buffalo grass made a remarkable attempt to increase its cover where it received some additional moisture.

Western Kansas pastures used at the rate of 20 acres per animal unit had a ground cover of about 26 percent. This cover was 15 to 16 percent better than heavily grazed pastures, but 5 to 6 percent less than that of similar use in central Kansas. This rate of moderate grazing allowed a reserve on some of the pastures, but not always. Grazing at a lighter rate tended to produce a better cover. Extremely light use or non-use did not seem to be significantly more efficient in aiding recovery than light use from 25 to 31 acres per animal unit.

Relics of *Hordeum pusillum* and *Lepidium densiflorum* were found to be abundant in most of the pasture in the region.

Numerous spots in the pastures had had their grass cover materially reduced or completely obliterated because of dusting from adjoining cultivated fields This reduction was found more frequently in the western part of the region.

Rotation of the grazing season tended to produce a better ground cover than continuous grazing at the same time each year.

Rotation of the use of the pasture during the growing season from year to year produced a better and more uniform cover of grass than that of non-rotated pastures which had had a lighter grazing load (pasture 3a, Table III). Winter grazing tended to produce a slightly heavier cover which was of the bunchy type.

LITERATURE CITED

ALBERTSON, F. W. Ecology of the mixed prairie in west-central Kansas. Ecology Monographs, 7:517-522. 1937.

BLACK, W. H., BAKER, A L., CLARK, V. I., and MATHEWS, O. R. Methods of grazing on native vegetation and gain of steers in Northern Great Plains. Government Printing Office. Technical Bulletin No. 547. March 1937.

SARVIS, J. T. Effects of different systems and intensities of grazing upon the native vegetation at the Northern Great Plains Field Station. Dept. Bulletin No. 1170. July 1923.

SAVAGE, D. A. and JACOBSON, L. A. The killing effect of heat and drought on buffalo grass and blue grama grass at Hays, Kansas. Jour. Am. Soc. of Agr., 27:(7)566-582. 1935.

SHANTZ, H. L. The natural vegetation of the Great Plains region. Ann. Assoc. Amer. Geog., 13:81-107. 1923.

TALBOT, M. W. Indicators of Southwestern range conditions. Government Printing Office. Farmers' Bulletin No. 1783. 1937.

United States Dept. of Agri. Soils and Men. Yearbook of agriculture. Government Printing Office. p1077-1078. 1938.

WEAVER, J. E. and CLEMENTS, F. E. Plant Ecology. McGraw-Hill Book Co., New York. 1938.

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Kansas Botanical Notes, 1941[1]

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The year as a whole was characterized by temperatures nearly normal, except for a hot July. The rainfall was above normal, so much so during a period in June and late September and October as to produce very high floods, approaching all-time records.

Among the numerous trees of Chinese elm (*Ulmus pumila*) thot to have been killed by the freezing weather of November, 1940, the season of 1941 disclosed that specimen and street trees were mostly only killed down to the ground and that sprouts either from the trunk close to the ground or from the roots came up freely in late spring. Trees that had been previously well trimmed showed less killing than trees which had received little or no trimming. Many supposedly dead trees were cut off at the ground level early in the year. Sprouts from such stumps were abundant, in many cases 1-1.5 meters in height. One tree which was allowed to remain standing during the summer had no sprouts at the end of summer, but within ten days after the tree was cut down in late September, several sprouts appeared from just above the ground.

During this year excessive crops of fruits were found on several kinds of trees, in each case tremendous crops over a wide area. The pods on the coffee tree (*Gymnocladus dioica*) made this tree particularly conspicuous in many woods where its presence had previously made little or no impression. Nearly everywhere one went, every coffee tree was certain to have a crown of pods, in some cases even trees not over 20 feet in height had more than 200 pods. This is the largest fruiting of coffee trees that I have seen in the past two decades. The tremendous crop of fruits on the hackberry (*Celtis occidentalis*) is also particularly worthy of note. So many were present that trees that normally are stripped of the fruits by birds by mid-summer had them way into the winter. Tree-of-Heaven (*Ailanthus altissima*) likewise was noted for the extraordinarily large number of samaras developed during the 1941 season. Pistillate trees usually have a few panicles of samaras each year, but in the 1941 season each pistillate tree seemed to have a panicle on nearly every branch. Such heavy crops have been noticed once or twice previously. On the other hand, arborvitae (*Thuja orientalis*) and the rough-leaved dogwood (*Cornus asperifolia*), both of which had such an excessive crop of fruit in 1940, had during 1941 an unusually small number of fruits.

A bulletin, "Weeds in Kansas," by the author, was published by the State Board of Agriculture toward the end of 1941 and may be obtained from the Secretary of the State Board of Agriculture, Topeka, Kansas. This bulletin contains descriptions, pictures, and methods of control for the 375 weeds of the state. The weeds are divided into three groups for treatment, the 20 most obnoxious having the most space devoted to them. They are *Convolvulus*

[1]Contribution No. 432 from the Department of Botany and Plant Pathology, Kansas State College of Agriculture and Applied Science.

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arvensis (field bindweed), *Convolvulus sepium* (hedge bindweed), *Centaurea picris* (Russian knapweed), *Lepidium draba* (hoary cress), *Sorghum halepense* (Johnson grass), *Apocynum cannabinum* (dogbane), *Gonolobus laevis* (climbing milkweed), *Polygonum coccineum* (swamp smartweed), *Franseria tomentosa* (bur ragweed), *Solanum carolinense* (Carolina niteshade, horse nettle), *Allium canadense* (wild onion or meadow garlic), *Tribulus terrestris* (puncturevine), *Ipomoea purpurea* (wild morning-glory), *Cuscuta pentagona* (dodder), *Rumex crispus* (curled dock), *Opuntia* spp. (prickly pear), *Symphoricarpos orbiculatus* (coralberry or buckbrush), *Vernonia interior* (ironweed), *Verbena stricta* (hoary verbena), and *Bromus japonicus* (Japanese bromegrass).

A second group of 81 taken together with the first group gives the 101 most important weeds in the state. Both of these groups have received major attention in the bulletin. The third group, including weeds which are scarce or of relatively little importance, have received less attention. There are lists of some of the important weeds in relation to various human activities, such as lawns, plant diseases, insect pests, and hay fever. Four color plates of four of the most important weeds are also included.

The major accessions to the Kansas State Herbarium during the year were a collection of Miami County plants from Bernard Rohrer, Gove County plants from Clement Weber, small collections from the Indian reservation in Jefferson County by Floyd Schultz, a few from Geary County by the author and miscellaneous specimens from various parts of the state.

Eight plants are to be added to the state list. One was found in Labette County by Mr. Duncan Gwartney. It is *Kickxia elatine* (L.) Dumort (the sharp-pointed toadflax), growing in sandy soil. A second and third were collected near Sedan in Chautauqua County, April 22, 1941, by L. H. Shinners, Grant Cottam and H. A. Stephens. They were *Chaetopappa asteroides* DC, and *Saxifraga texana* Buckl. The fourth was the bulrush, *Scirpus heterochaetus Chase.* It is No. 485 of Uhler and Warren, collected June 3, 1929 in Barton County and cited by A. A. Beetle (Amer. Jour Bot. 28: 691-700. 1941) as being in the U. S. National Herbarium at Washington, D. C. A fifth is *Geranium pusillum* Burm. collected at Lebo, Coffey Co., by A. Carr in 1933. It was determined by C. V. Morton of the U. S. National Museum recently. A sixth is *Xanthium spinosum* L. (the spiny clotbur), found in Marion County in the fall of 1941 by F. A. Hagans, the county agricultural agent. A seventh is *Aplectrum hyemale* (Muhl.) Torr. from Leavenworth County by J. V. Kelly. The eighth is *Eleocharis parvula* (R & S) Link, collected 7 miles northwest of Concordia, Cloud County by S. V. Fraser in September, 1941, and identified by H. K. Svenson. Specimens of all except the fourth are in the State Herbarium at Manhattan.

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Anatomy of Taraxacum Officinale 'Weber'

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"Although the composite family is one of the largest in the plant kingdom, it includes relatively few representatives of economic importance" (1). *Taraxacum offincinale* 'Weber' is undoubtedly of negative economic importance in that much time and money are spent in trying to eradicate it from lawns, although it does have some medicinal value.

A search of the literature reveals very little study made of the anatomy of *Taraxacum officinale* 'Weber'. Rimbach (3) made a study of the contraction of underground stems of several plants including *Taraxacum officinale* 'Weber'. Schmalfuss (4), after a study of intercalary growth in Glumiflorae and flower scapes, reported on the occurrence of division figures and the length of pith cells in the scape of *Taraxacum officinale* 'Weber'. Takenouchi (5) made a study of the variation of waviness in the lateral walls of epidermal cells of leaves in sunshine and shade individuals of the same species. One of the plants included in his study was *Taraxacum officinale* 'Weber'. Keil (2) made a study of the root type of *Taraxacum officinale* 'Weber' and its response to soil types.

The desired parts were fixed in form-acetic-alcohol, sectioned, and stained with safranin and malachite green

According to Keil (2), the basic root form is a well-defined tap root which tapers gradually downward from the crown and which has several strong lateral roots as well as numerous fine roots. The lateral roots are arranged in two rows which wind clockwise downward in a loose spiral around the root and are distributed more or less regularly along its entire length. The short vertical stem passes evenly over into the root.

In observing slides of the root-stem transition, it is possible to notice the progressive changes in the position of the leaf traces with their vascular bundles. In the upper part of the root, leaf traces do not seem to be very prominent. The few which can be seen are in a loose ring among the parenchyma cells. In a section from higher up, the leaf traces and their bundles are easily distinguished. Some of the traces are nearer the periphery. Yet nearer the apex, we notice for the first time that leaf traces are appearing in the center of the root crown (Fig. A). The last section studied shows the petiole of a leaf in which the main vascular bundles are seen in cross sections of the petiole. Haward (1) said, concerning the vascular transition, "Regardless of type of transition, the essential point of transition is that a reorientation of primary vascular tissues is effected so that vascular continuity may be established and maintained".

The stem of *Taraxacum officinale* 'Weber' is fairly round and is smooth except for scars left where leaves have been broken off it. It is quite short; usually one to two and one-half centimeters long, and seldom extends above ground level. Rimbach (3) reported that underground stems which push

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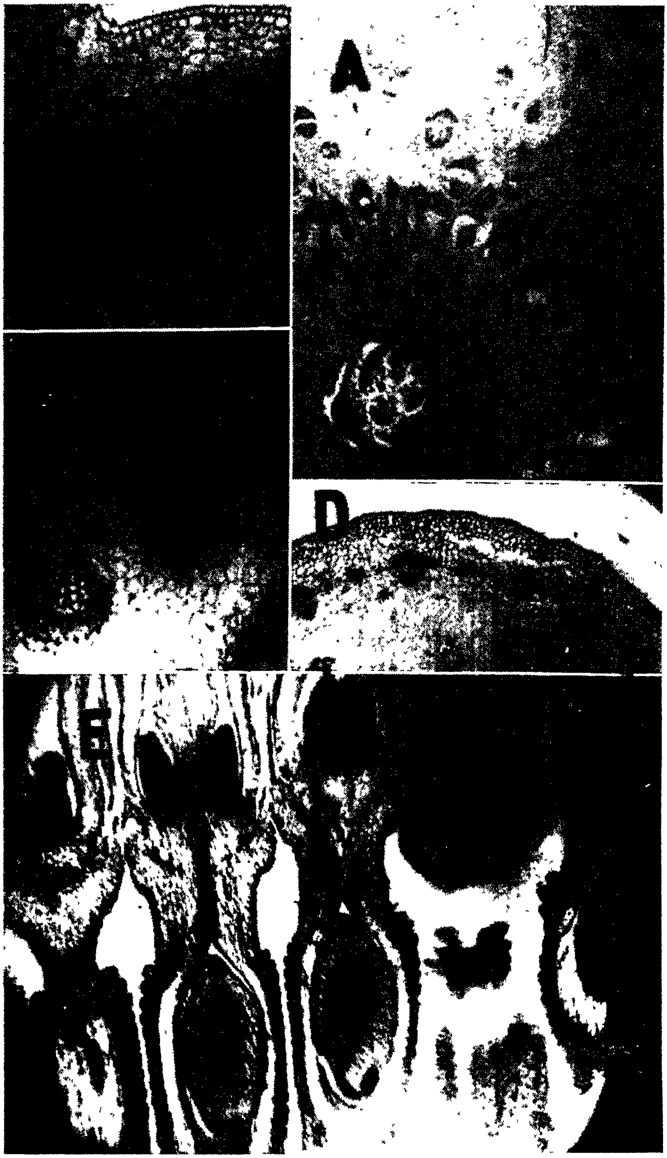

DESCRIPTIONS OF FIGURES

Fig. A—Section of root-stem transition zone; 25X

Fig. B—Section of midrib of shade leaf showing large lysogenous area; 110X

Fig. C—Section of midrib of sun leaf showing lysogenous area: 110X

Fig. D—Section of scape; 25X

Fig. E—Portion of flower head; 110X

above the ground and bear rosettes of leaves are in some cases contracted, pulling the leaves against the soil. *Taraxacum officinale* 'Weber' showed the greatest contraction of those he studied.

The epidermis of the stem is a single row of regular, lightly-cutinized cells. Beneath the epidermis are two to four rows of fairly compact collenchymatous cells among which may be found many leaf traces with their collateral type of vascular bundles. The traces are arranged cyclically in uneven rings.

The leaves branch off the sides and top of the stem. They vary in color from light to dark green, and in some instances are modified by a reddish or brown pigment. The leaves vary in length from six to twenty centimeters. The petiole is nearly as long as the blade. There is a prominent midrib with numerous veins branching off it. The margins of the leaves are very irregular and are deeply incised at three or four somewhat regular intervals.

The epidermis of the leaf is a single layer of cutinized cells. Takenouchi (5) reported that waviness of the epidermal cells increased in proportion to the depth of shade. We found no such correlation. The mesophyll of the sun leaf is much denser than in the shade leaf, and as a result the sun leaf is greener and it is also thicker than the shade leaf.

The lysogenous area in the midrib of the shade leaf (Fig. B) was much larger than that in the sun leaf (Fig. C). There were regularly three large fibrovascular bundles in the midrib of the shade leaf and five in the midrib of the sun leaf.

The scape varies in length from 4 to nearly 45 centimeters. The diameter of the scape decreased along its length from bottom to top. A cross section of the scape (Fig. D) shows a single layer of epidermal cells inside which are three layers of fairly compact collenchymatous cells. Most of the remainder is composed of parenchyma in which the vascular bundles occur. There is a single cycle of about 32 regularly arranged vascular bundles in the scape.

A longitudinal section of the scape reveals the bundles made up of annular, spiral, and scalariform elements. The vessels measure 1.5 microns in diameter. The parenchymatous cells are 40 to 120 microns in length. This is nearly in agreement with Schmalfuss (4) who gave them as being 18 to 148 microns in length. The scape is hollow.

The inflorescence of *Taraxacum officinale* 'Weber' is usually 2 to 3 centimeters broad, and is bright yellow in color. The head contains 125 to 200 individual flowers. The style divides into two stigmas which are 1 to 1.5 millimeters in length and .06 millimeters in diameter. The inner surfaces of the stigmas are more heavily covered with fine hairs which aid in collecting and holding the pollen. The warty spherical pollen grains are 30 microns in diameter. The flower has a single ovary containing an anatropous ovule (Fig. E). The nectaries, as shown in Fig. E, are egg-shaped structures around the base of the style inside the corolla tube.

The combined length of the pappus and achene of *Taraxacum officinale* 'Weber' is 1.5 to 1.9 centimeters. The pappus consists of a single row of bristles 6 millimeters long set on the enlarged upper end of the stalk. The length of the achene alone is about 3.1 millimeters and the diameter is nearly 1 millimeter. There are 4 longitudinal spiny ridges on the achene.

SUMMARY

Standard methods of preparation were used. The root is that of a typical dicotyledon. The short vertical stem contains collateral type vascular bundles arranged cyclically. Sun leaf was thicker and greener and the midrib had a smaller lysogenous area than that of the shade leaf, but no correlation was noted between waviness of epidermal cells and light intensity. The hollow scape contains much collenchyma and about 32 vascular bundles made up of various tracheary elements. The inflorescence contains about 150 flowers having a 2-parted stigma and a single anatropous ovule. The warty spherical pollen grains measured 30 microns, and the corolla tube contains nectaries. The fruit is an achene with 4 longitudinal spiny ridges and a parachute made up of a single row of bristles.

LITERATURE CITED

1. HAYWARD, H. E. The Structure of Economic Plants. The Macmillan Company, New York, 1938.
2. KEIL, GERHARD. Das Wurzelwerk von Taraxacum officinale 'Weber'. Eine untersuchung uber den Bewurzelungs und seine Beeinflussung durch den Boden. Beigh. Bot. Centralbl. Abt. A 60 (½) ; 57-96. 3 pl. 9 fig. 1940. (n.v. abst. in Biol. Abst. 15 entry 16404).
3. RIMBACH, A. Uber Verkurzung von Stengeln (contraction of stems.) Ber. Deutsch. Bot. Ges. 44 (5) :335-338. 1926. (n.v. Abst. BA 2 entry 5104).
4. SCHMALFUSS, KARL. Untersuchung uber die interkalare Wachstumszone an Glumifloren und dikotylen Blutenschaften. (Intercalary growth in Glumiflorae and flower scapes). Flora 24 (4) :336-366. 7 fig. 1930. (n.v. BA 6 entry 14210).
5. TAKENOUCHI, MAKOTO Investigations on the relation between plants and their surrounding conditions by the quantitative method. IV. On the variation of waviness in the lateral walls of epidermal cells of leaves in sunshine and shade individuals in the same species. (In Japanese, with English summary.) Bulteno Sci. Fakult, Terkult. Kjusu Imp. Univ. 4 (3) :191-217. 3 fig. 1931. (n.v. BA 7 entry 2244).

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Study of the Woody Plants Along the Streams Which Cross Ellis County, Kansas

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The study, of which this paper is a report, was conducted during the summer of 1941 and dealt with the kinds, age, size, and location of the various species and the soil in which they were growing. Woody plants of Ellis county are mostly limited to the three streams which cross the county.

METHODS

Transects, one rod in width and extending across a stream bed so as to include all woody plants, were run across each stream at the western edge, the center, and the eastern edge of the county. All the woody plants in each transect were graphed.

The diameter of the trees was taken by means of a calibrated wooden square and their age was determined by the use of the Swedish increment borer.

Soil samples were taken within the area of the transects.

All transects were selected, as nearly as possible, as typical places of the woody vegetation, and attention was paid as to whether or not they were grazed.

SPECIES ON EACH STREAM

As shown from findings within the transects only, the Saline river and Big creek had about the same total kinds of species. The Saline river had 11 species; Big creek, 10 species; and the Smoky Hill river, 4 species.

The total number of all species shows that Big creek had many more than either of the other two streams. Big creek had a total of 149; the Saline river, 80; and the Smoky Hill river, 35.

DEAD TREES

There were 4 dead standing trees along the Smoky Hill river and 7 dead stumps; all of these were cottonwoods.

There were 5 dead standing trees along the Saline river, 4 elms and 1 hackberry; there were also 8 dead stumps of ash.

Big creek had no dead trees or stumps within the transects; but, as on the other streams, general observations revealed that dead trees were present but not so many as along the other two streams.

LIVING TREES—KIND AND NUMBER

Taking the major species found along all three streams for comparison as shown on Table I, Big creek had 96; the Saline river, 51; and the Smoky Hill river, 34.

The ash was most numerous with 50 specimens. The hackberry 35, the elm 10, the cottonwood 1; and there was 1 clump of willows.

The ash was most numerous on the Saline river with 19 specimens while the elm had 17, the hackberry 13, the cottonwood 2; and there were no willows.

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General observations along the stream outside the transects revea willows.

The cottonwood was most numerous on the Smoky Hill river with 18 specimens while the willow had 15, the ash 1; and there were no hackberry or elm.

LIVING TREES—SIZE AND AGE

The average age and size of trees as shown on Table 1 shows that Big creek led with an average age for all major species of 42.6 years and 13.4 inches. The Saline river was next with 32.1 years and 8.4 inches. The Smoky Hill river was last with 8.1 years and 3.9 inches. The average age and size for all the major species from all three streams were 26.5 years and 8.1 inches.

The oldest kind of trees on Big creek was the elm with an average of 23.1 years; the hackberry was next with 15.5 years; then, the ash, with 11.5 years; no willows were listed. There was one exception, a large, lone cottonwood with an estimated age of 120 years.

The largest kind of trees on Big creek was elm with an average diameter of 9.35 inches; hackberry was next with 2.7 inches; then, ash with 2.6 inches. The lone cottonwood referred to in the preceding paragraph had a diameter of 39 inches.

The estimated average height of the trees along Big creek was about 20 feet.

Some interesting information concerning cottonwoods which were planted a short distance from the transect in the west-central part of the county on Big creek as related by Mr. J. F. Stebbins, a neighboring farmer, follows:

Diameter of tree	Age of tree
27 inches	67 years
23 inches	67 years
44 inches	67 years

The oldest kind of trees on the Saline river was cottonwood with an average of 52 years; elm was next with 31.4 years; then, ash with 25.5 years; hackberry with 19.5 years and no willows listed.

The largest kind of trees on the Saline river was cottonwood with an average diameter of 16 inches; elm was next with 8.6 inches; ash with 5.7 inches; and hackberry with 3.3 inches; no willow listed.

The estimated average height of the trees along the Saline river was about 20 feet.

Several large cottonwoods had been washed up against the bridge east of the transect in the northwest corner of the county on the Saline river and had been dragged out along the side of the road. These had been washed there by the recent high water.

An interesting observation was made about one-half mile south of the transect on the Saline river in the northwest corner of the county in a grove of trees planted by the father of Maggie Lynd and related by her as follows:

Cottonwood

Age	Diameter
59 years	27½ inches (lone tree by house)
58 years	31 inches (in grove)
58 years	19 inches (in grove)
58 years	14 inches (in grove)
58 years	16 inches (in grove)

EXPLANATION OF PLATE

Fig.
IV. A general view along the Saline river.
V. A general view along Big creek.
VI. A general view along the Smoky Hill river.


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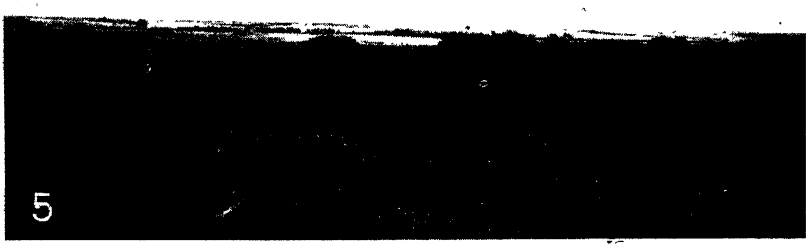
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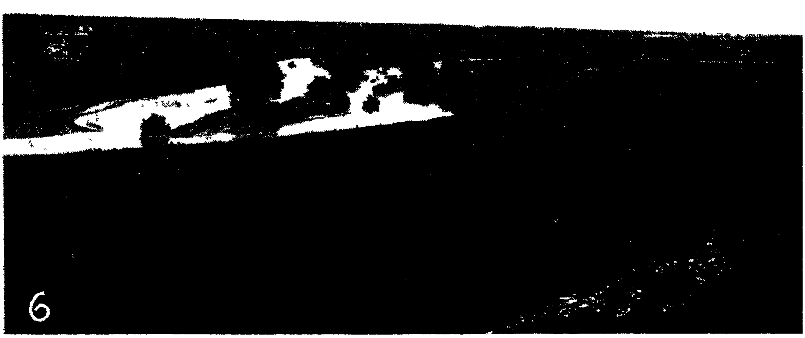
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Boxelder

Age	Diameter
58 years	21 inches (in grove)
58 years	13 inches (in grove)
58 years	17 inches (in grove)

Ash

Age	Diameter
58 years	6 inches (in grove)
58 years	6½ inches (in grove)
58 years	8 inches (in grove)
58 years	4 inches (in grove)

Hackberry

Age	Diameter
58 years	49 inches (lone tree)

The above measurements were just samplings taken out of the grove which was planted in a square; the diameters were taken by the writer.

The oldest kind of trees on the Smoky Hill river was cottonwood with an average of 11.9 years; willow was next with an average of 6.5 years; and ash, with 6 years; no elm or hackberry listed.

The largest kind of trees on the Smoky Hill river was cottonwood with an average diameter of 9.5 inches; willow was next with 1.6 inches; and ash, with 0.5 inches; no elm or hackberry listed.

The wife of the tenant on the M. L. Gorham estate where the transect in the northeast corner of the county on the Smoky Hill river was run, told the writer that all the trees in the pasture west of their house washed out in the flood of 1939. These trees were cottonwoods.

SHRUBS AND WOODY VINES

The Saline river had the greatest number of shrubs and woody vines and also the most species. The species found were as follows:

False indigo (Amorpha fruticosa L.)
Buckbrush or coralberry (Symphoricarpus orbiculatus Moench.)
Snowberry (Symphoricarpus occidentalis Hook.)
Choke Cherry (Prunus virginiana demissa (Nutt.) Torr.)
Smooth sumac (Rhus glabra L.)
Ill scented sumac (Rhus trilobata Nutt.)
Poison Ivy (Rhus toxicodendron L.)
Wild currant (Ribes odoratum Wendl.)
Wild grapevine (Vitis vulpina L.)
Wild Rose (Rosa sp.)

Big creek was next in number and species of shrubs and woody vines which were as follows:

Choke Cherry (Prunus virginiana demissa (Nutt.) Torr.)
False indigo (Amorpha fruticosa L.)
Poison Ivy (Rhus toxicodendron L.)
Wild grapevine (Vitis vulpina L.)

The Smoky Hill river had fewer shrubs and woody vines than either of the other streams, and they were practically limited to the one species:

False indigo (Amorpha fruticosa L.)

SEEDLING TREES

The greatest number of seedling trees was noted on Big creek. The following kinds were noted: elm, ash, willow, and cottonwood.

The Saline river was next in the number of seedlings, and the kinds noted were: ash, elm, and hackberry.

The Smoky Hill river had very few seedlings, and these were cottonwood and willow.

SOIL

The soil samples from the Smoky Hill river were very sandy.

The soil samples from the Saline river were not so sandy as the Smoky Hill river soil but still quite inclined to the sandy side.

The soil samples from Big creek were less sandy than either of the other two groups and were of a sandy loam or garden loam type.

DISTANCE FROM CHANNEL

There was also a noticeable variation in the diameter and age of trees growing near the stream and those growing farther away. This variation is clearly shown in Table No. II. In general, the trees within the first ten feet of the stream channel were older and larger. The main exception was on the Smoky Hill river where the largest and oldest trees were between twenty and thirty feet from the stream channel. The interval of from ten to twenty feet from the stream channel along this stream indicated no trees and might be explained by moisture near the channel and anchorage farther back holding the trees, while the change of currents and sandy soil in the center interval combined to cause this absence of trees.

SUMMARY AND CONCLUSION

The total of all species along Big creek was 149 as compared to 80 on the Saline river and 35 on the Smoky Hill river.

The total number of the major kinds of trees along Big creek was 96 as compared to 51 on the Saline river and 34 on the Smoky Hill river. The percentages of the major kinds of trees were as follows: Big creek 53%, Saline river 28%, and Smoky Hill river 19%.

The percentages of each major kind was as follows: ash 38%, hackberry 26%, elm 15%, cottonwood 12%, willow 9%.

The major kinds of trees in order of size from the largest average were as follows: cottonwood 21.5 inches, elm 9.0 inch, hackberry 3.0 inches, ash 2.9 inches, and willow 1.6 inches in diameter.

The major kinds of trees in order of average age from the oldest were as follows: cottonwood 61 3 years, elm 27.3 years, hackberry 17.2 years, ash 14.3 years, and willow 6.5 years.

The Saline river had more shrubs and more woody vines than the other streams with Big creek next and the Smoky Hill river last, having little other than false indigo.

The ash, elm, and cottonwood apparently showed more evidence of dead material than the other species, and this material was about evenly divided between the Saline river and the Smoky Hill river.

There were more seedlings along Big creek than the other streams. The Saline river was next with quite a few and the Smoky Hill river last with practically none.

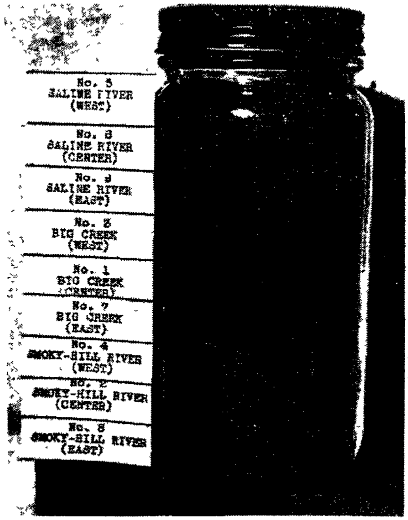
EXPLANATION OF PLATE

Fig.

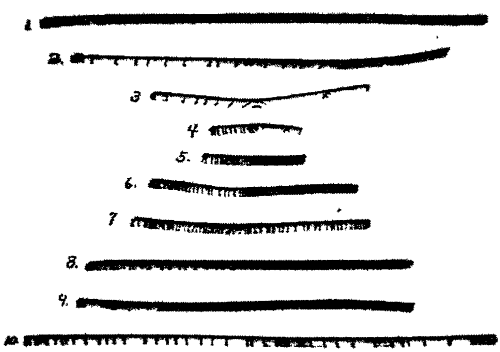
I. Soil samples from west to east along the Saline river at the top of jar, Big creek in the middle of jar and the Smoky Hill river at the bottom of the jar.

II. Cores from increment borings to determine diameters. Note variations of growth rings. 1 & 2 are elm, 3, 4, 5, 6, & 7 are hackberry, 8, 9, & 10 are cottonwood.

III. Growth next to stream indicating larger trees nearer stream.


SALINE RIVER (WEST)
SALINE RIVER (CENTER)
SALINE RIVER (EAST)
BIG CREEK (WEST)
No. 1 BIG CREEK (CENTER)
No. 7 BIG CREEK (EAST)
No. 4 SMOKY-HILL RIVER (WEST)
No. 2 SMOKY-HILL RIVER (CENTER)
SMOKY-HILL RIVER (EAST)

1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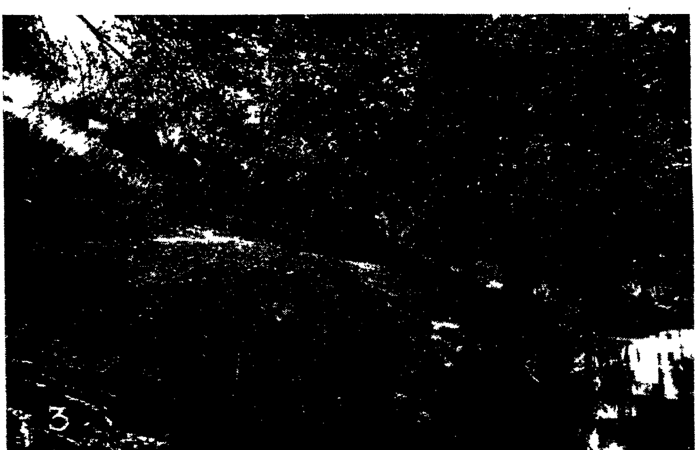

The soil was best along Big creek, followed by the Saline river soil; then the Smoky Hill river soil, which was very sandy.

In general, larger and older trees were found nearer the stream, especially within the first ten feet.

The condition of the soil for anchorage and retention of moisture as well as furnishing nutrients may account for the noticeable difference of tree, woody vine, and shrub growth in this county.

TABLE I.—Number, average age, and average diameter of the most numerous kinds of trees along the three streams which cross the county.

Big Creek	Ash	Hackberry	Am. Elm	Cottonwood	Willow	Total
Number	50	35	10	1	1 clump	96
Av. Age, Years	11.48	15.48	23.1	120?	....	42.56
Av. Diameter, Inches	2.64	2.73	9.35	39	....	13.43
Saline River						
Number	19	13	17	2	....	51
Av. Age, Years	25.47	19.54	31.41	52	....	32.1
Av. Diameter, Inches	5.67	3.29	8.64	16	....	8.4
Smoky Hill River						
Number	1	....	....	18	15	34
Av. Age, Years	6	....	....	11.89	6.53	8.14
Av. Diameter, Inches	.5	....	....	9.46	1.61	3.86
Total						
Number	70	48	27	21	15	181
Av. Age, Years	14.32	17.15	27 25	61.3	6.53	26.45
Av. Diameter, Inches	2.94	3.01	8.99	21.49	1.61	8.08

The above observations were from the transects only.

TABLE II.—The average diameters and ages of trees at ten-foot intervals from the stream channels.

		Av. Diameter, Inches	Av. Age, Years
Big Creek	0-10 Ft.	4.33	18.00
	10-20 Ft.	3.86	13.73
	20-30 Ft.	2.75	12.38
Smoky Hill River	0-10 Ft.	1.18	6.18
	10-20 Ft.	0.00	0.00
	20-30 Ft.	9.19	16.33
Saline River	0-10 Ft.	6.50	3.05
	10-20 Ft.	5.00	26.46
	20-30 Ft	5.18	22.77

The above observations were from the transects only.

12

Notes on Plant Diseases in Kansas in 1941[1]

C. O. JOHNSTON, Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture

During the period from 1935 to 1938, the writer, in collaboration with others, published a series of articles dealing with annual observations on plant diseases in the State, entitled "Kansas Mycological Notes." (1, 2, 3, 4).

The present article is a revival of that series of notes and it is planned to prepare similar articles annually. These will record the important or unusual plant disease developments in the State, as well as the prevalence and severity of certain economically important diseases each year. It is not claimed that the list will be complete for all of the diseases occurring in Kansas each year, but, it will include all those of importance.

The unusual weather conditions that prevailed in much of Kansas during the spring and summer of 1941 favored many unusual disease developments on cultivated crops and native vegetation. In the western part of the State good rains during the late summer and fall of 1940, with the consequent restoration of subsurface soil moisture, resulted in a considerable increase in the vegetation and produced the best stands and growth of winter wheat that had been obtained in that area in many years. These conditions followed by a mild winter and exceedingly heavy rains in May and June, 1941, and a second period of heavy rains in September and October resulted in unusually heavy infections of many diseases.

IMPORTANT OR UNUSUAL DEVELOPMENT OF DISEASES OF CEREAL, FORAGE, AND FIBER CROPS

The short period of extreme heat in July, 1940, followed by good rains in August resulted in the appearance of unusually large amounts of volunteer wheat, oats, and barley. The same conditions also favored over-summering of cereal rusts and heavy infections developed on volunteer grains during the late summer and early fall. By the middle of October volunteer plants of oats and barley were heading; such plants usually were heavily infected with stem rust. Considerable crown rust, (*Puccinia coronata*) appeared on volunteer oats late in October but did not become so abundant as stem rust (*P. graminis avenae*). Both leaf rust (*P. rubigo-vera tritici*) and stem rust (*P. graminis tritici*) infection were heavy on volunteer winter wheat in the eastern half of the State and leaf rust was abundant in western counties. Infection became so severe in many fields of early sown wheat in the central part of Kansas that much of the top growth was destroyed and the amount of fall pasture seriously reduced.

The absence of killing frost at the normal time favored the development of all of these rusts up to the sudden severe freeze of November 11, 1940.

[1]Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Kansas Agricultural Experiment Station. Contribution No. 433, Department of Botany and Plant Pathology, Kansas State College.

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Extremely low temperatures at that time killed volunteer oats and barly and all rusts on those crops disappeared rapidly. Urediospores of stem rust collected on dead oats and barley plants in December and in January, 1941, failed to germinate. Stem rust on winter wheat declined rapidly in abundance after the freeze of November 11, but a little infection still could be found in late December. After the first of January stem rust uredia could be found only on dead leaves and the spores failed to germinate. It seems unlikely, therefore, that stem rust on wheat, barley, and oats, and crown rust on oats overwintered as far north as Manhattan, Kansas, in 1940-41.

Leaf rust of wheat also decreased in abundance after the severe freeze of November 11, 1940, but it could be found with considerable ease in nearly all fields throughout the winter. By the middle of February fresh uredia began to appear and it became clear the leaf rust was overwintering in unusually large amounts. The surprising feature of the situation was the occurrence of overwintering in the western part of the State. This was due to the mild winter, the abundance of rust in the fall, and the heavy top growth of winter wheat, which provided ample protection for uredia on leaves near the ground.

Although leaf rust of wheat overwintered in Kansas in considerable abundance, cool, dry weather during April and the early part of May prevented the rapid increase of rust from overwintered infection centers and there was not an unusually large amount of leaf rust in the State until after the middle of May. However, there were severe infections of leaf rust in Oklahoma and Texas before that time and extremely heavy showers of spores from these sources occurred in Kansas during the last half of May. This, combined with frequent heavy rains, wet soil, and heavy dews, resulted in a rapid increase in infection. By June 1, leaf rust had appeared in nearly all fields in alarming proportions, and it was soon evident that Kansas was experiencing an epiphytotic of leaf rust fully as severe as that of 1938. Maximum infection was not reached so early in 1941 as in 1938, and loses, therefore, were not so heavy; but it is estimated that leaf rust caused a reduction of at least five percent in the yield of the 1941 Kansas wheat crop.

The wet weather of May and June also favored the development of other rusts. Crown rust appeared on oats in the eastern half of Kansas early in June and rapidly increased to epiphytotic proportions. By June 15 crown rust infection was the heaviest the writer ever has observed in Kansas and most oats in the eastern half of the State were badly lodged as a result of a combination of heavy crown rust infection and torrential rains. The losses due to crown rust on oats undoubtedly were heavier than those caused by leaf rust on wheat.

Stem rust (*Puccinia graminis*) was present on wheat, oats, and barley by the middle of June but infection was late in appearing and developed less rapidly than is usually expected, because of temperatures slightly too low for the rapid spread of those rusts. Losses were severe in some localities but were not so large or widely distributed as in 1935 and 1937—years of severe stem rust epiphytotics. The advent of hot weather and rapid maturity of crops shortly after June 20 prevented large late-season losses. In the case of stem rust on wheat, it was notable that Kanred had much less infection in 1941 than other hard red winter varieties. This apparently was due to the prev-

alence of physiologic race 17 to which Kanred is resistant. Race 17 has been increasing in prevalence in Kansas for two years.

Other rusts of unusual severity in Kansas in 1941 were leaf rust of rye (*Puccinia rubigo-vera secalis*), leaf rust of barley (*P. anomala*), and rust of flax (*Melampsora lini*). Leaf rust on rye was the heaviest the writer has ever observed, and experimental plots of Common Winter and Balbo varieties were severely damaged. Leaf rust of barley, although relatively rare in Kansas, was severe on both winter and spring barley at Manhattan. Flax rust, which likewise seldom occurs in Kansas, produced a moderate infection in experimental plots at Manhattan. Considerable infection occurred on Linota and light infection was present on Redwing. Bison had less infection than the other two varieties.

Another rust that seldom appears in abundance in Kansas, but was fairly abundant in 1941, was sorghum rust (*Puccinia purpurea*). As usual the disease did not appear until early October. Thereafter, it was abundant on the lower leaves of Atlas sorgo at Manhattan.

Rust on alfalfa (*Uromyces striatus*) also appeared in late summer and fall in the north central part of the State.

Several diseases of cereal crops, usually considered of minor importance in Kansas, were present in abundance in 1941. Mildew (*Erysiphe graminis*) was particularly severe on wheat and barley in the early spring. On wheat this disease reached the greatest severity ever observed and undoubtedly caused some reduction in yield through early defoliation of plants in lowland fields. Speckled leaf blotch (*Septora tritici*) and glume blotch (*S. nodorum*) were abundant on winter wheat. The former was particularly severe in the southeastern one-fourth of the State and it was noted that the variety Kawvale was extremely susceptible. Many fields of Kawvale in that area were prematurely defoliated by *S. tritici*. Glume blotch was most severe in south-central counties and was associated with severe lodging of wheat during the wet weather of June. Loose smut of wheat (*Ustilago tritici*) continued to be an important disease in the State in 1941, although apparently it was not so severe as in recent years. There was a larger increase in eastern counties where the susceptible variety Clarkan is increasing in acreage than in other parts of the State.

DISEASES OF MINOR IMPORTANCE OR OF ORDINARY SEVERITY IN 1941

Many other diseases of cultivated and uncultivated plants were present in Kansas in ordinary or minor amounts. In addition a few diseases of unusual occurrence but minor importance were noted. Among the latter those of particular interest were bacterial blight of barley (*Phytomonas translucens*), wilt of flax (*Fusarium lini*), mosaic of smooth brome grass (virus), rust on hollyhock (*Puccinia malvacearum*), and rust on giant ragweed and cocklebur (*Puccinia xanthii*).

Bacterial blight of barley seldom is severe in Kansas but in 1941 several varieties in experimental sowings at Manhattan were heavily infected. The variety Kusan was destroyed before maturity.

Although flax has been grown in the State for many years there have been few reports on the occurrence of wilt. Within recent years wilt has appeared in experimental sowings of flax at Columbus and Thayer. In 1941 there were

a few reports of wilt in commercial fields of flax in southeastern counties.

Rust on hollyhock occasionally has been reported from the extreme eastern part of the State but it seldom has been seen as far west as Manhattan. Infection was heavy on both young and old plants at Manhattan in October and November, 1941.

Another rust of unusual severity in the vicinity of Manhattan in the fall of 1941 was *Puccinia xanthii* on giant ragweed and cocklebur. In some low places along the Kansas river infection was so heavy that many plants of *Xanthium pennsylvanicum* were killed before frost.

Mosaic of smooth brome grass appeared in the grass headlands and borders surrounding the cereal rust nursery at Manhattan. This is an unusual disease in that it persists from year to year owing to the perennial habit of the host. Dr. H. H. McKinney of the Bureau of Plant Industry, United States Department of Agriculture, has proved that the disease is transmissable to wheat. Some yellow mosaic appeared on wheat plants in the plots adjacent to infected brome grass. Considerable yellow mosaic was noted in wheat fields of southern Saline and Dickinson Counties. Some fields were so severely damaged that the yields were extremely low.

LITERATURE CITED

1. Lefebvre, C. L., and C. O. Johnston. Kansas Mycological Notes, 1934. Trans. Kans. Acad. Sci. 38:101-103. 1935.
2. ———. Kansas Mycological Notes, 1935. Trans. Kans. Acad. Sci. 39:95-101. 1936.
3. Johnston, C. O., C. L. Lefebvre, and E. D. Hansing. Kansas Mycological Notes, 1936. Trans. Acad. Sci. 40:69-74. 1937.
4. ———, and Travis E. Brooks, Kansas Mycological Notes, 1937. Trans. Kans. Acad. Sci. 41:121-123. 1938.

13

The Effect of Climate and Different Grazing and Dusting Intensities Upon the Yield of the Short-Grass Prairies in Western Kansas

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The past few seasons have been trying ones on the vegetation of central and western Kansas. Rainfall has often been as much as thirty per cent below average. This deficiency of precipitation was accompanied by low relative humidity and high temperatures which reduced the amount of soil moisture to the point of non-availability during long periods of time, for both cultivated and native plants.

These adverse climatic conditions in themselves would be enough to greatly reduce plant cover and forage production. In addition, farmers for economic reasons or otherwise, did not reduce the number of livestock, which resulted in further depletion of pastures already weakened by drought. Dust, blown from cultivated fields, also played an important role in decreasing the cover of the native pastures. On numerous occasions vast areas of native vegetation were completely covered by layers or drifts of dust from adjacent farm land. The purpose of this problem was to determine the effect of climate, amount of dusting, degree of grazing, and grasshopper injury upon the quantity and quality of forage produced by various short grass pastures in west-central Kansas. Since it was impracticable to determine quantitatively the amounts of short grass cover and forage produced in large plots, this study was made on areas one meter square. The plots chosen were as nearly as possible representative of the different types of pastures studied.

RELATED STUDIES

Many experimental studies of clipping have been conducted to determine the mineral and chemical composition of forage under different grazing conditions. Studies have also been made to determine the effect of clipping upon the amount of forage produced, and the amount of food in storage organs. These studies were conducted in widely different localities and with various plants, usually under controlled greenhouse conditions. Hase (1941) investigated the effect of clipping upon the spread of grass seedlings, and found that root systems and forage yields were retarded by clipping. Harrison (1939) found that greenhouse-grown alfalfa gave diminishing returns in root and top growth in direct proportion to the decrease in height and intensity of clipping. This was also true for the stored starch present.

Stapledon and Milton (1930) found that cocksfoot plants cut eight times to 6 inches in height considerably outyielded those cut ten times to ground level. D. G. Sturkie (1930) studied the influence of various topcutting treatments on rootstocks of Johnson grass. Experimental evidence shows that any cutting treatment reduces the root development, and the more frequently the cutting is made the greater is the reduction. Grandfield (1935) found that early and frequent cutting of alfalfa resulted in a lower carbohydrate and

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nitrogen content of the roots when determinations were made at the end of the growing season. Harrison (1939) in working with the response of Kentucky blue grass to variation in temperature, light, cutting, and fertilizing found that short and frequent defoliations were harmful to rhizomes and roots and that plants grew very little at 100 degrees F. after defoliating. Harrison and Hodgson (1939) in studying the response of perennial grasses to cutting treatments found that, in general, the shorter a given grass was cut, the less top growth it produced. The yields of underground parts decreased with increase in severity of clipping treatment. Stansel, Reynolds and Jones (1939) in studying the pastures of Texas, found that heavy grazing decreased the forage production of native grasses, and increased the yield of weeds.

DESCRIPTION OF REGION WHERE STUDY WAS CONDUCTED

The areas selected for study near Hays and Phillipsburg, Kansas, are typical of the blue grama-buffalo grass faciation on the rolling topography of the mixed prairie region of the west-central portion of the state. The elevation is slightly more than 2000 feet above sea level. The soil is a fine textured, silty, clay loam (Albertson, 1937). Soils on the lower hillsides and ravines have been gradually built up from eroded materials carried down the hills by water and gravity.

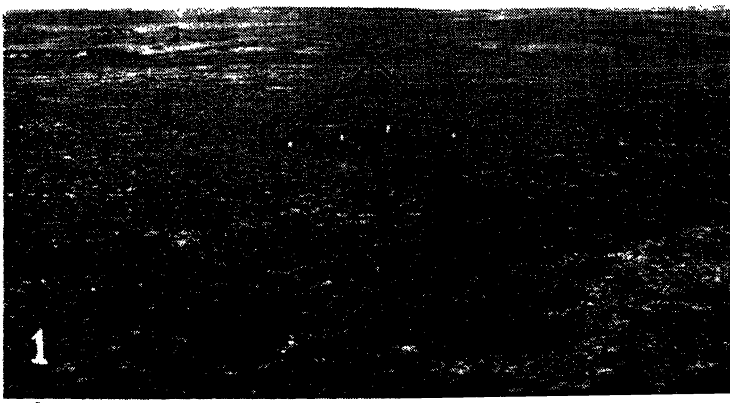
The climate of this region varies considerably. The growing season is approximately 165 days in length. High temperature, low relative humidity, and a comparatively high wind velocity are common. The winters are usually mild. The major part of the precipitation of from 20 to 25 inches per year is received during the growing season.

There are three general types of vegetation, with varying degrees of intermixtures, common to the region where this study was conducted. The short grass type composed of buffalo grass (*Buchloe dactyloides*), and blue grama (*Bouteloua gracilis*), in approximately equal amounts, occupies the major portion of this region (Albertson, 1937). It also occurs at the bases of the hills and frequently on the slopes. The mid-grass type composed of little bluestem (*Andropogon scoparius*), and side-oats grama (*Bouteloua curtipendula*), dominate the hillsides and shallow ravines. Big bluestem (*Andropogan furcatus*) is limited to the lowlands and well watered places.

ENVIRONMENTAL CONDITIONS DURING PERIOD OF STUDY

PRECIPITATION—The total annual precipitation at Hays in 1939 was 15.85 inches (Table 1). This was 7.84 inches below normal. In 1940, however, the precipitation of 22.91 inches was .32 inch above normal. At the Phillipsburg station, the precipitation of only 13.36 inches in 1939 was 9.91 inches below normal. In 1940 it was 17.90 inches, a deficiency of 5.37 inches.

TEMPERATURE—The mean monthly temperature and the deviation from normal for the months of April to September inclusive, are given in Table 2. This period is considered the growing season and is, therefore, the most critical for plant growth. The mean temperature at the Hays station for these months during 1939 and 1940 are considerably above the normal, especially during the summer of 1939. In 1940 the temperature was still above average, but not as excessively so as in 1939. The 1939 growing season at the Phillipsburg station had above normal temperatures in all months except August. In 1940, it was only slightly above normal for all months.



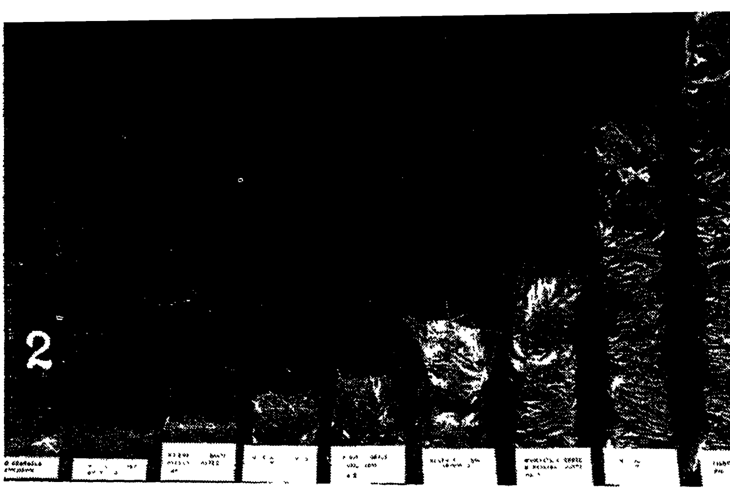


Fig. 1.—Small exclosure used in study. It is to protect two quadrats from livestock.

Fig. 2.—Photograph to show graphically the relative amount of short grass produced under different environmental and grazing conditions for a period of two years. (From left to right) : Overgrazed, Phillipsburg; Heavily Dusted, Phillipsburg; Moderately Grazed, Heavily Dusted, Hays; Moderately Grazed, Hays; Heavily Grazed Until 1935, Hays; Moderately Grazed, Phillipsburg; Moderately Grazed, Moderately Dusted, Hays; Non-grazed, Hays; Lightly Grazed, Hays.

TABLE 1.—Monthly and annual precipitation with deviations from normal at Hays and Phillipsburg, Kansas, during the years of 1939 and 1940.

Month	Hays 1939	Hays 1940	Phillipsburg 1939	Phillipsburg 1940
January	.48	.72	.57	.60
February	1.05	.35	.52	.68
March	.98	.83	2.54	1.73
April	1.65	1.57	1.35	1.13
May	1.00	2.41	.83	3.01
June	4.71	2.36	3.59	.44
July	1.04	4.21	.90	1.54
August	3.53	3.30	2.24	2.94
September	.42	3.14	.10	1.62
October	.18	.62	.14	1.56
November	.11	2.58	.T	1.99
December	.70	.82	.58	.66
Total	15.85	22.91	13.36	17.90
Normal	23.69	22.59	23.27	23.27
Deviation	—7.84	+.32	—9.91	—5.37

TABLE 2.—Monthly temperatures (T), with deviations (D) from normal, for the growing season, at Hays and Phillipsburg, Kansas, during 1939 and 1940.

Station	April T	April D	May T	May D	June T	June D	July T	July D	August T	August D	September T	September D
Hays, 1939	53.7	+1.1	68.6	+6.6	75.4	+2.8	84.7	+6.1	78.0	+0.6	75.2	+6.5
Hays, 1940	54.0	+1.4	63.2	+1.2	74.6	+2 0	82.4	+3.8	75.4	—2.0	71.4	+2.7
Phillipsburg, 1939	53.8	+1.0	70.1	+7.7	76.1	+4.1	85.0	+5.9	78.0	—0.3	75.6	+6.9
Phillipsburg, 1940	52.2	—0.6	62.8	+0.4	75.8	+3.8	83.4	+4.3	76.4	—1.3	70.6	+1.9

SOIL MOISTURE—Soil moisture determinations were made on the moderately grazed area at Hays, and on the non-grazed and heavily grazed areas at Phillipsburg. The samples were taken to a depth of 5 feet once each month during the growing season. The percentage of soil moisture above the hygroscopic coefficient is considered to be the amount of water available for plant growth.

At Hays, moisture was available in the top 6 inches of soil until July, in 1939. During the remainder of the season, water was unavailable to plants at all depths except in a few cases of negligible amounts below 3 feet (Table 3). Soil moisture was available for plant growth in the top 6 inches of soil during most of the 1940 season. Below this level it was unavailable in most cases, except in August when there was a small amount available in the first foot.

In 1939 the soil on the non-grazed location at Phillipsburg had available moisture in the upper 24 inches during the month of May (Table 4). During July and August moisture extended to 12 inches below the surface, but in September none was available below 6 inches. In 1940 available moisture was present in May and August to a depth of 12 inches. At the lower levels the moisture was unavailable during both seasons.

The soil moisture on the overgrazed area at Phillipsburg was available to a depth of 12 inches during May, 1939. During June and August the available moisture extended only to a depth of 6 inches, and none was present at any of the depths for July and September. The only available soil moisture present during the 1940 growing season was in May when it was present to 12 inches,

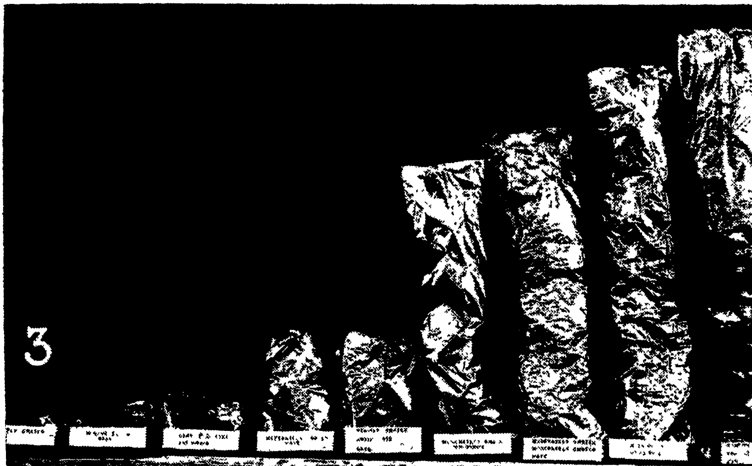


Fig. 3.—Photograph to represent the amount of annual weeds produced from the same quadrats as given in Figure 2. (From left to right): Lightly Grazed, Hays; Non-grazed, Hays; Heavily Dusted, Phillipsburg; Moderately Grazed, Hays; Heavily Grazed Until 1935, Hays; Moderately Grazed, Phillipsburg; Moderately Grazed, Moderately Dusted, Hays; Overgrazed, Phillipsburg; Moderately Grazed, Heavily Dusted, Hays.

Fig. 4.—Meter quadrat in non-grazed short grass area at Hays, Kansas. Basal cover in the fall of 1940 was 38.7 per cent.

TABLE 3.—Percentage of available soil moisture in the moderately grazed short grass type at Hays, Kansas, for the growing seasons of 1939 and 1940.

	May		June		July		August		September	
	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940
0- 6"	3.5	7.3	0.5	4.0	2.9	—5.3	—3.4	13.3	—4.2	1.5
6-12"	1.7	1.3	—0.7	0.6	—.2	—1.2	—1.8	1.3	—2.5	0
12-24"	—1.0	—2.5	—1.6	—2.1	—1.3	—1.7	—2.2	—1.2	—1.8	—0.5
24-36"	—1.5	—1.7	—0.1	—2.3	—0.1	—1.8	—1.3	—1.9	—1.5	—2.7
36-48"	—1.5	—0.5	0.9	—0.6	0.3	—0.6	0.5	0.4	0.3	—2.0
48-60"	—1.1	0.9	1.0	1.4	1.8	0.0	1.3	0.6	0.5	—1.2

TABLE 4.—Percentages of available soil moisture at the Phillipsburg locations for the growing seasons of 1939 and 1940.

		May		June		July		August		September	
Depth	Location	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940
0- 6"	non-grazed	15.8	15.9	—4.9	—1.5	3.8	—7.5	3.7	—7.4	4.2	—2.5
	overgrazed	11.3	11.5	1.7	0.6	—2.1	—3.0	4.7	—5.0	—5.1	—1.5
6-12"	non-grazed	15.1	13.3	—2.0	—0.6	3.1	—2.8	0.4	—1.6	—0.4	—1.0
	overgrazed	7.3	2.4	—0.8	0.0	—2.9	—0.2	—1.3	—1.7	—0.5	—0.4
12-24"	non-grazed	8.8	—0.6	0.1	—1.0	0.0	—1.8	—1.3	—0.1	—1.2	0.0
	overgrazed	—1.8	—2.0	—0.8	—1.4	—1.5	—1.5	—1.1	—1.4	—1.6	—0.9
24-36"	non-grazed	—0.6	—1.5	—1.0	—1.2	—1.7	—2.1	—1.5	—1.5	—1.6	—1.7
	overgrazed	0.2	—0.6	0.1	—0.7	0.0	—0.1	—0.6	0.0	—0.1	0.3
36-48"	non-grazed	0.3	—0.8	—0.7	—0.7	—1.0	—1.4	0.2	0.4	—0.3	—0.1
	overgrazed	0.9	0.5	0.5	0.6	0.9	1.2	0.5	0.5	0.2	1.0
48-60"	non-grazed	3.1	0.0	0.5	0.4	0.1	0.2	0.4	0.4	0.6	0.8
	overgrazed	1.6	0.8	1.0	0.9	0.9	0.7	—0.2	1.3	0.6	0.5

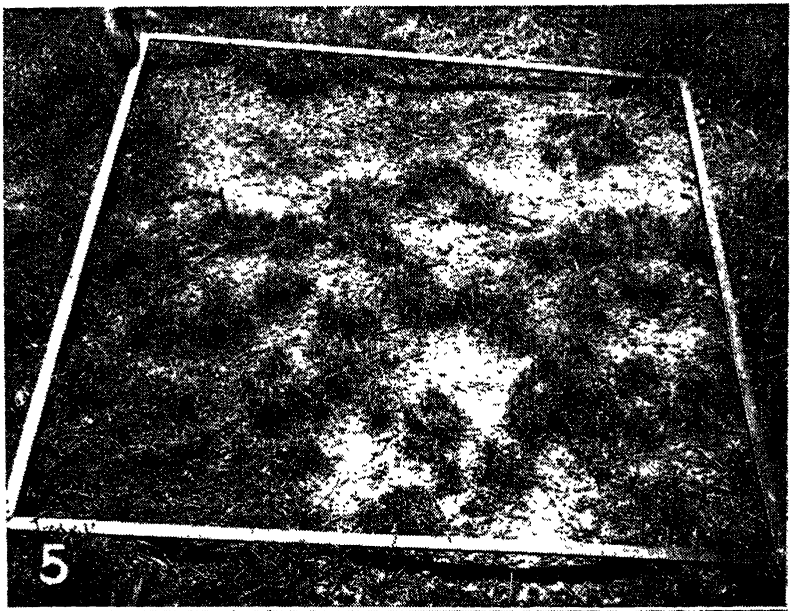
and in August when it extended to only 6 inches. The overgrazed location had less soil moisture in the upper 12 inches than did the non-grazed. This difference may be due to the more abundant vegetation of the non-grazed quadrats holding a greater quantity of snow and rainfall. However, when considerable moisture was available the soil in the non-grazed area held slightly less moisture in the lower levels, due probably to a greater number of roots which resulted in a greater loss of water through transpiration.

METHOD OF STUDY

Two one-meter quadrats were staked out adjacent to each other in each area selected near Hays and Phillipsburg, Kansas. These areas were representative of the region under study. They were protected from grazing by barbed wire exclosures (Figure 1). During 1939 some quadrats were protected from grasshopper infestation by a cover of window screen. All the quadrats were charted in the early summer of 1939 and 1940 with a pantograph to determine the percentage of short grass cover. The grass was clipped at such intervals as to simulate, as nearly as possible, average grazing conditions. All vegetation, both annuals and short grass, was air-dried and weighed. The percentage of cover and total amount of forage in pounds per acre for each year were determined.

Precipitation and temperature records were obtained for 1939 and 1940 from the Government Weather Bureau (Flora, 1940). The amount of soil moisture was determined each month to a depth of 5 feet from samples secured by use of a geotome.

The following classification of the pastures selected for study is based upon the factor having the greatest influence upon the condition of the pasture when the problem was initiated: (1) non-grazed, (2) lightly grazed, (3) moderately grazed, (4) heavily grazed until 1935, and lightly grazed thereafter, (5) overgrazed, (6) moderately dusted, and (7) heavily dusted.



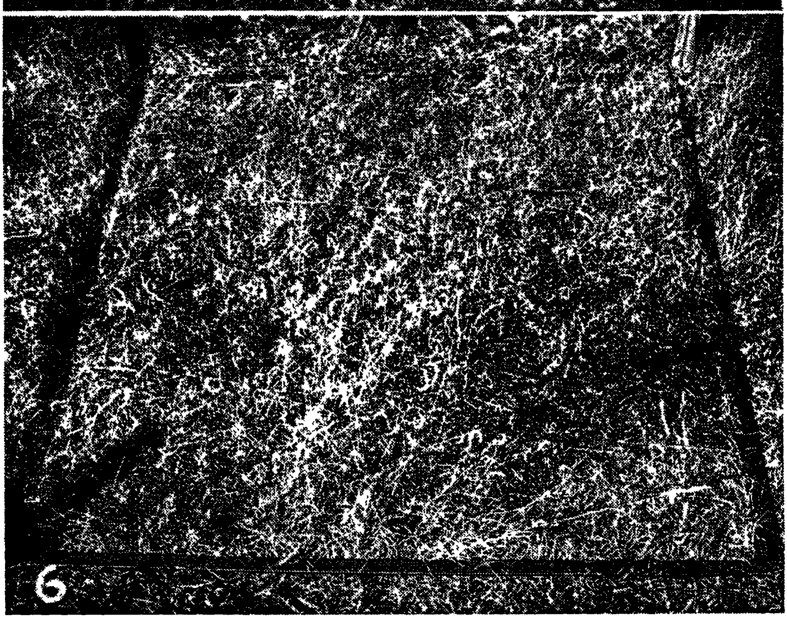


Fig. 5.—Meter quadrat in non-grazed short grass at Phillipsburg, Kansas. The basal cover of 18.6 shows clearly the destructive effects of drought.

Fig. 6.—Meter quadrat in lightly grazed short grass range at Hays, Kansas. The cover in 1940 was 92.8 per cent.

Since this classification was made on the basis of the intensity of grazing and dusting at the time the study was initiated, it would not apply to seasons of optimum temperature, rainfall and soil moisture conditions.

The non-grazed areas were those where grazing was not practiced at all, or it was restricted to light grazing during winter months. In some cases a crop of hay was removed during late summer or early autumn.

Pastures with a grazing intensity of 30 acres or more per year for each animal unit were considered lightly grazed. The area selected at Hays had been subjected to a very careful grazing program. The owner of the pasture had practiced deferred grazing during the years of excessive drought prior to this study. All livestock was removed when climatic conditions became too adverse for continued production of short grass.

Pastures of 20 to 30 acres for each animal unit were classed as having been moderately grazed. These locations at both Hays and Phillipsburg were not subjected to heavy grazing during early spring or winter. Watering and salting places were also distributed over the pasture in such a manner as to furnish good range utilization.

The overgrazed areas had a grazing intensity of less than 15 acres per animal unit. The one at Phillipsburg was grazed at the rate of 4 acres per animal unit for year-long utilization.

Unless otherwise specified, all the areas were subjected to light dusting during the years prior to this study. The most severe dust storms occurred in 1935, when layers of silt often several inches in depth settled on the vegetation. Since light dusting was constant over the area it was not considered a deciding factor in producing the variation in ground cover or forage production of short grass.

At the Hays station some of the moderately grazed areas were also heavily or moderately dusted. At Phillipsburg, however, only those heavily dusted were studied. The heavily dusted locations were in close proximity to plowed fields in which the soil was in a finely pulverized condition. The grass in the area selected for study was often entirely covered by a blanket of dust. During 1939 the dusted areas at Hays were heavily infested with grasshoppers. After repeated counts, it was found that approximately 6 grasshoppers were on each square foot of ground.

RESULTS

The results of this study are presented in the order of increasing intensity from the non-grazed to the heavily grazed and heavily dusted conditions.

NON-GRAZED.—The basal cover on the non-grazed quadrats at Hays increased from 36.4 per cent in 1939 to 38.7 per cent in 1940 (Table 5). The forage production, however, lost slightly from 1978 pounds per acre in 1939 to about 1941 pounds in 1940. The production of weedy annuals such as *Hordeum pusillum, Lepidium densiflorum*, and others, decreased from 176.2 pounds per acre in 1939 to 80.3 in 1940.

At Phillipsburg the two quadrats were selected on a non-grazed area. One quadrat was composed of blue grama (*Bouteloua gracilis*), and spring annuals such as *Hordeum pusillum, Lepidium densiflorum,* and others. The basal cover of blue grama decreased from 57.6 per cent in 1939 to 18.6 per cent in 1940. The forage yield was reduced from 608 pounds per acre in 1939 to 174 pounds in 1940. The depleted condition of the grass may be noted

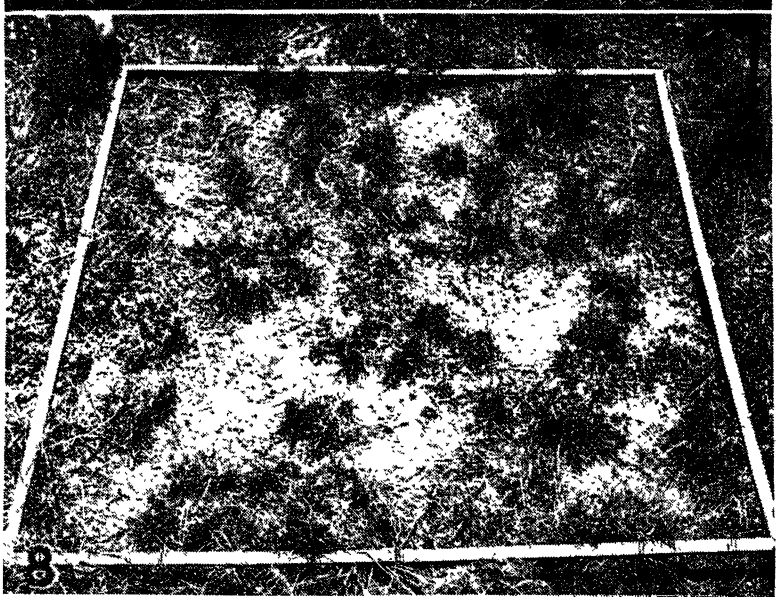


Fig. 7.—Meter quadrat in moderately grazed short grass range at Hays, Kansas. The cover at Hays, Kansas. The cover in 1940 was 31.7 per cent.

Fig. 8.—Meter quadrat in moderately grazed pasture of short grasses at Phillipsburg, Kansas. The cover in 1940 was 15.4 per cent.

from Figure 5. The forage production of the annuals decreased from 962 pounds per acre in 1939, to 828 pounds in 1940.

The cover on the meter quadrat located in the side-oats grama decreased from 28.9 per cent in 1939 to zero in 1940. The yield suffered a similar fate, being 832 pounds per acre in 1939 and nil in 1940. However, the weed production increased from 556 pounds per acre in 1939 to 2295 pounds in 1940.

LIGHTLY GRAZED.—The basal cover and forage production were much better on the lightly grazed areas than on those non-grazed at Hays (Table 5). The cover on this well managed range was 86.6 per cent in 1939, and 92 in 1940. The short grasses, especially buffalo grass, covered the ground in a dense mat, and remained fairly green during most of the dry season of 1939. The yield of short grass was 2362 pounds per acre in 1939. In 1940 the yield

TABLE 5.—Per cent basal cover and yield in pounds per acre of short grass and weedy annuals.

		Per cent cover		Pounds per acre Grass		Pounds per acre Weeds	
Location	Condition	1939	1940	1939	1940	1939	1940
Hays	Non-grazed	36.4	38 7	1978	1941	176.2	80.3
Phillipsburg	Non-grazed, Bouteloua gracilis	57.6	18.6	608	174	962	828
Phillipsburg	Non-grazed, Bouteloua curtipendula	28.9	0	832	0	556	2295
Hays	Lightly grazed	86.6	92	2362	2731	90	T
Hays	Moderately grazed	28.9	31.7	455	444	3.6	819
Phillipsburg	Moderately grazed	49.8	15.4	1226	267	419	1689
Hays	Heavily grazed until 1935, lightly thereafter	24.7	17.3	412	445	98	384
Phillipsburg	Overgrazed	25.6	.48	272	7.2	108	2377
Hays	Mod. dusted, without grasshopper infestation	27.7	33.1	1206	1045	301	2367
Hays	Mod. dusted, with grasshopper infestation	27.8	36.8	59.9	992	246	2269
Hays	Heavily dusted, without grasshopper infestation	4.9	5.5	445	205	928	2577
Hays	Heavily dusted, with grasshopper infestation	4.5	4.3	126	127	976	2501
Phillipsburg	Heavily dusted	13.3	0	293	0	148	2520

on the same area was increased to 2731 pounds. The weed production, chiefly *Hordeum pusillum*, was 90 pounds in 1939, but dropped to only a trace in 1940.

MODERATELY GRAZED.—Short grass cover on the moderately grazed location at Hays increased from 28.9 per cent in 1939 to 31.7 in 1940. During the hot summer months of both 1939 and 1940 the grass was dry and brown for several weeks at a time on this area, consequently, there was little change in cover. The forage production of short grass in 1939 was 455 pounds per acre, and only 11 pounds less (444) in 1940. There was a great increase in the number of weedy annuals during the season of 1940, as indicated by the increase from only 3.6 pounds per acre in 1939, to 819 pounds in 1940.

At Phillipsburg the short grass cover on the moderately grazed quadrats suffered a significant loss during these two seasons. In 1939 it was 49.8 per cent, while in 1940 it had been reduced to only 15.4 per cent. The grass was fairly green during a part of June of 1939, but during the remainder of the season it was dry and brown. These extremely dry conditions had a very pronounced effect upon the production of vegetation. The yield was decreased from 1226 pounds per acre in 1939 to 267 pounds in 1940. With the decrease in cover and yield of short grass there was a significant increase in the weed population. The yield of weeds in 1939 was 419 pounds per acre, and 1689 pounds in 1940. The condition of the grass in September, 1940, is shown in Figure 8.

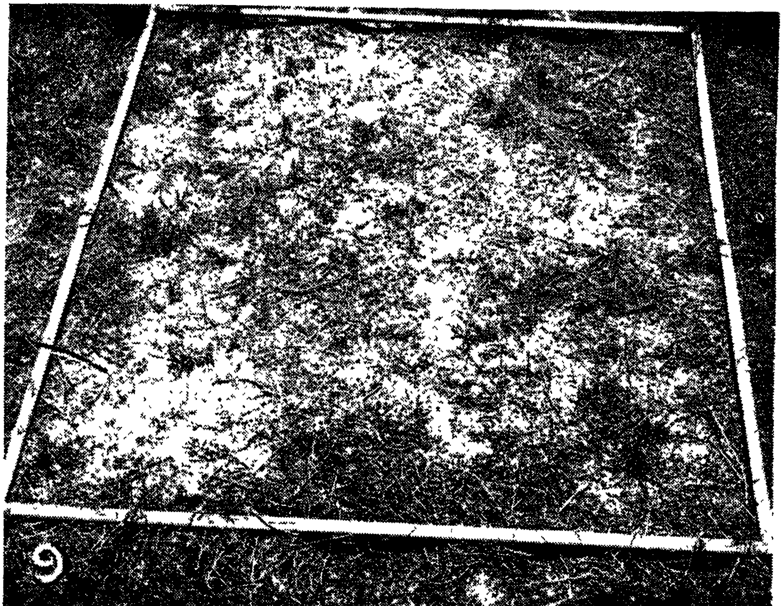


Fig. 9.—This barren meter quadrat is typical of the overgrazed short grass at Phillipsburg, Kansas. The cover in 1940 was only .48 per cent. All weeds were removed before photograph was taken.

Fig. 10.—Meter quadrat on the heavily dusted short grass type at Phillipsburg, Kansas. No grass was alive when the photograph was taken in 1940.

HEAVILY GRAZED UNTIL 1935, LIGHTLY THEREAFTER.—These quadrats, near Hays, had a short grass cover of 24.7 per cent in 1939, while in 1940 it was 17.3 per cent. The production of short grass forage was 412 pounds per acre in 1939 and only slightly more (445 pounds) in 1940. Annual weeds such as *Hordeum pusillum, Plantago purshii, Lepidium densiflorum,* and others, produced 98 pounds of forage per acre in 1939, and 384 pounds in 1940.

OVERGRAZED.—This pasture at Phillipsburg had been heavily grazed for years prior to this study. The quadrats selected had a 25.6 per cent ground cover of short grass in 1939, and only .48 per cent in 1940. Figure 9 shows the depleted condition of the quadrats on September, 1940. The grass was very short and dry during most of the growing season of 1939, and did not have sufficient stamina to survive the winter of 1939. This area produced 272 pounds of short grass forage per acre in 1939, and only 7.2 pounds per acre in 1940. Conversely to the loss of short grass cover and forage production was the large increase of weedy annuals such as *Salsola pestifer, Amaranthus retroflexus,* and *Chenopodium album.* These plants produced 108 pounds of forage per acre in 1939, and 2377 pounds in 1940.

DUSTING AND GRASSHOPPER INFESTATION.—At the Hays station, areas moderately dusted and heavily dusted were found to be badly infested with grasshoppers. The cover on the moderately dusted areas without and with grasshopper infestation was about the same through both seasons. In 1939 the areas without infestation had a cover of 27.7 per cent. In 1940 it had increased to 33 1 per cent. The infested quadrats had a cover of 27.8 per cent in 1939, and 36.8 per cent in 1940. Even though the increase in cover from 1939 to 1940 was not significantly different in the areas without and with infestation, there was a marked reduction in yield in the infested areas when compared to those not infested. The moderately dusted area without infestation yielded 1206 pounds of short grass per acre in 1939 and 1045 pounds in 1940. Similar areas with infestation produced only 59.9 pounds of short grass in 1939 and 992 pounds in 1940.

There was no significant difference in the yield of weeds whether or not the areas were infested with grasshoppers. In 1939 the production was 301 and 246 pounds per acre respectively for the areas without and with infestation. The more favorable growing conditions of 1940 caused a very definite increase in the yield in 1940 over that of 1939. The area without infestation produced 2367 pounds of weeds per acre while the infested area produced 2269 pounds per acre.

The heavily dusted areas without infestation had only 4.9 per cent short grass cover in 1939, and 5.5 per cent in 1940. This is much less than that of the moderately dusted quadrats subject to the same degree of grazing and grasshopper infestation (Table 5). This area produced 445 pounds of short grass forage per acre in 1939 and 205 pounds per acre in 1940. The annual weed production, composed chiefly of *Salsola pestifer, Amaranthus retroflexus,* and *Chenopodium album,* was 928 pounds per acre in 1939. This production was increased to 2577 pounds in 1940.

The areas heavily dusted and with grasshopper infestation had a cover of 4.5 per cent in 1939, and 4.3 in 1940. This was only slightly less than where protection from grasshoppers was afforded (Table 5). The yield of short grass, however, was greatly reduced, being 126 and 127 pounds per acre re-

spectively for 1939 and 1940. The acre yield of weeds was 976 pounds in 1939 and 2501 pounds in 1940. This was not greatly different than on the areas protected from grasshoppers.

HEAVILY DUSTED.—These areas located at Phillipsburg had 13.3 per cent short grass cover and produced 293 pounds of forage per acre in 1939. By June, 1940, the dust had completely smothered out the short grass. The barren condition of the location after the annuals had been removed is shown in Figure 10. With this depletion of grass the production of annuals increased from 148 pounds per acre in 1939, to 2520 pounds in 1940 (Table 5).

SUMMARY

1. The non-grazed quadrats produced a good yield of short grass, but less than that of the lightly grazed plots. This indicates that a well managed grazing program is beneficial to the short grasses.
2. The forage yield and per cent ground cover of short grass were greatest on lightly grazed quadrats.
3. Moderate grazing maintained a constant forage yield and short grass cover, except under extremely adverse climatic conditions, when a considerable decrease in short grass yield and cover was noted.
4. Careful grazing practices following heavy grazing caused an increase in forage yield, but not on the basal cover of short grass.
5. Overgrazing caused an enormous reduction of short grass forage production, and a corresponding loss in ground cover: conversely an increase in weedy annuals was generally the result.
6. Dusting caused an enormous loss in production of short grass forage and per cent ground cover Weedy annuals, however, made a great increase.
7. Heavy infestation of grasshoppers reduced short grass yield.

LITERATURE CITED

ALBERTSON, F. W. Ecology of the mixed prairie in West-Central Kansas Ecological Monographs 7:486-490. 1937.

FLORA, S. D. Climatological Data, Kansas Section. United States Weather Bur. 53:97-103. 1940.

GRANDFIELD, C. O. The trend of organic food reserves in alfalfa roots as affected by cutting practices. Jour. of Agri., Res. 50:697-709. 1935.

HARRISON, C. M. Greenhouse studies of the effect of clipping the tops of alfalfa at various heights on the production of roots, reserve carbohydrates, and top growth. Plant Physiology 14:505-516. 1939.

HARRISON, C. M. and HODGSON, C. W. Response of certain perennial grasses to cutting treatments. Jour. Am. Soc. of Agron. 31:418-430. 1939.

HASE, C. L. The effect of clipping and weed competition upon the spread of pasture grass seedlings. Trans. Kans. Acad. of Science. 44:104-115. 1941.

STANSEL, R. H., REYNOLDS, E. V. and JONES, J. H. Pasture improvement in the gulf coast prairie of Texas. Tex. Agri. Exp. Sta. Bull. No. 570. 1939.

STAPLEDON, R. G. and MILTON, W. E. J. The effect of different cutting and manure treatments on the tiller and root development of cocksfoot. Welsh Jour. of Agri. 6:166-174. 1930.

STURKIE, D. G. The influence of various top-cutting treatments on rootstocks of Johnson grass. Jour. Am. Soc. of Agron. 22:82-92. 1930.

14

The Relation of Depth of Planting to the Morphology of the Wheat Seedling[1]

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The subcrown axis of *Triticum vulgare* Vill. has been variously called the rhizome, subcrown internode and mesocotyl. The term mesocotyl is objectionable for a number of reasons. It has been applied to portions of the axis, which in the case of oats is the hypocotyl and in the case of corn and wheat is the epicotyl. It is not, therefore, applied consistently to the same region of the axis. Furthermore, the term could be interpreted to mean "between cotyledons" or possibly a region "between hypocotyl and epicotyl". The term should be replaced with correct terms. Normally the elongated portion of the subcrown axis consists of only one internode but may consist of two or more if the seedings are made at depths greater than two or three inches. The fact that more than one internode may occur in the subcrown axis would make the term rhizome preferable, even though the occurrence of more than one internode in the elongated portion of the axis is rare when seedings are made at the usual depths. The term rhizome is commonly defined as an underground stem. From it shoots and adventitious roots may arise. This is true in the case of wheat. At seeding depths greater than two or three inches the rhizome frequently has distinct nodes from which normal foliage leaves, tillers and adventitious roots arise (Fig. 1). This leaves no doubt that the subcrown axis is a rhizome. Normal rhizomes, in addition to the elongated internode, have at least one or two other internodes, depending upon the interpretation of the anatomy of the root-stem-transition zone of the axis. At greater seeding depths there may be four or five and possibly as many as six internodes in the rhizome.

The literature of the seedling morphology and anatomy of the grasses has been reviewed by Van Tieghem (8), Bruns (2), Avery (1) and summarized by McCall (4). Avery (1) reviews briefly the historical development of the ideas concerning the rhizome of cereals. At the present time it is accepted that the elongated portion of the rhizome is an internode, but whether it is the second or third internode remains controversial. Avery (1) considers the scutellar node to be the first node. According to this view the elongation of the wheat rhizome occurs in the second internode. McCall (4) considers the scutellum to be "the functional cotyledon", divergent from the second node. The epiblast is regarded as a "vestigial leaf" and to be located at the first node or the root-stem-transition zone. This view holds that the wheat rhizome elongates in the third internode, the crown developing normally at the fourth node. The writer believes that McCall's evidence is convincing.

In preliminary studies at Manhattan, Kansas, it has been found that depth of seeding has a marked effect on the morphology of the wheat seedling. This effect has been noted by Percival (6), Webb and Stephens (9) and

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Taylor and McCall (7). Effects of temperature on morphology have been casually observed and noted by Dickson (3) and McKinney (5). In addition interesting observations have been made by Taylor and McCall (7) as result of carefully controlled experiments to show the effects of temperature on the wheat seedling.

Figure 2 illustrates the effect of depth of seeding on the length of the rhizome of Fulcaster wheat. The plantings were made at depths of three-fourths of an inch, one and three-fourths inches, two and one-half inches, four inches and six inches. Approximately fifty days after planting the plants were cut off at the soil line and the underground parts collected for observation and photographing. Observations on other varieties would seem to indicate that the depth of the crown for a variety is not constant for any depth of planting. There were some indications of differences in the extent and number of roots for each depth of planting.

Beyond depths of two or three inches a number of morphological variations may occur. An Oro wheat seedling was found showing a well developed tiller at the fourth node and a normal crown at the fifth node (Fig. 1, A). The depth of seeding was two and one-half inches. A Kanred seedling which was planted at a depth of four inches developed a normal leaf at the fourth node (Fig. 1, B). The crown developed at the fifth node. In the case of a Harvest Queen seedling planted at a depth of four inches, the crown began to develop at the fourth node but the main axis continued to elongate to form the crown at the sixth node (Fig. 1, C). The fifth node remained close to the fourth node as shown by the presence of two normal leaves close together on the axis. At the time of collection the leaves from the fourth and fifth nodes were green above ground but were brown beneath. A Turkey seedling which was planted at a depth of six inches began development of the crown at the fifth node but the main axis continued to elongate and the crown eventually formed at the seventh node (Fig. 1, D). The sixth node remained close to the fifth node as shown by the presence of two leaves close together on the axis. A tiller had begun development in the axil of the leaf at the sixth node. A leaf had developed at the fourth node but was nonfunctional at the time of collection.

Comparatively little work has been done on the factors affecting the underground morphology of the wheat plant and no definite information is available on the physiology of the rhizome and the formation of the crown. The effects of temperature in elongating the rhizome have been utilized by McCall (4) in his anatomical studies. Figure 1 suggests that greater seeding depths in combination with temperature effects would be of value in anatomical studies. As indicated by the work of Webb and Stephens (9) there is definite need of a comprehensive study of the relation of seeding depth and environmental factors to the morphology and physiology of wheat varieties.

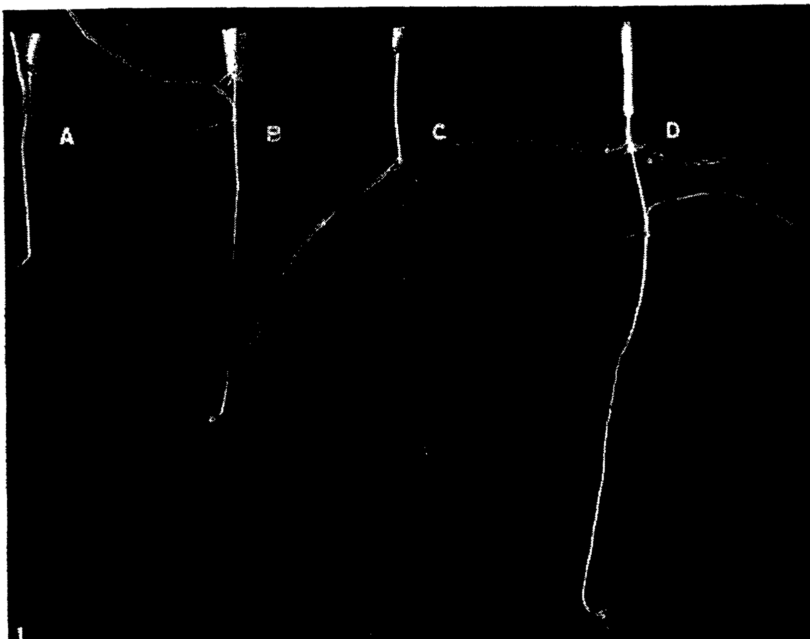
SUMMARY

Varying the depth of seeding produces variation in the length of the rhizome and in the location of the crown as shown in two figures.

EXPLANATION OF FIGURES

FIGURE 1. The effect of seeding depth on the early morphology of wheat. A, Oro seedling. B, Kanred seedling. C, Harvest Queen seedling. D, Turkey seedling.

FIGURE 2. The effect of seeding depth on the development of the rhizome of Fulcaster wheat. A, three-fourths of an inch. B, one and three-fourths inches. C, two and one-half inches. D, four inches. E, six inches.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A
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LITERATURE CITED

1. AVERY, G. S., JR., Comparative anatomy and morphology of embryos and seedlings of maize, oats, and wheat. Bot. Gaz., 89:1-39. 1930.
2. BRUNS, E., Der Grasembryo. Flora. 76:1-33. 1892.
3. DICKSON, J. G., Influence of soil temperature and moisture on the development of the seedling-blight of wheat and corn caused by *Gibberella saubinettii.* Jour. Agr. Research, 23:837-870. 1923.
4. MCCALL, M. A., Developmental anatomy and homologies in wheat. (Triticum vulgare Vill.). Jour. Agr. Research, 48:283-321. 1934.
5. MCKINNEY, H. H., Influence of soil temperature and moisture on infection of wheat seedlings by *Helminthosporium sativum.* Jour. Agr. Research, 26:195-218. 1923.
6. PERCIVAL, J., The wheat plant; A monograph. London. 1921.
7. TAYLOR, J. W. and MCCALL, M. A., Influence of temperature and other factors on the morphology of the wheat seedling. Jour. Agr. Research, 52:557-567. 1936.
8. VAN TIEGHEM, P., Observations anatomiques sur le cotyledon des Graminees. Ann. Sci. Nat. Bot., 5:236-276. 1872.
9. WEBB, R. B. and STEPHENS, D. E., Crown and root development in wheat varieties. Jour. Agr. Research, 52:569-583. 1936.

15
Indications of Hail Resistance Among Varieties of Winter Wheat[1]

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Crop damage by hail is one of the many hazards incident to production of winter wheat. Smith (8) summarized data collected over a period of 11 years which showed that approximately one-twentieth of all weather damage to wheat grown in the United States was caused by hail. This was about one-half the amount caused by diseases or insects. Loss in wheat as the result of hail storms is a tragedy familiar to everyone who has had contact with the growing of wheat. There were 75 hail storms reported in Kansas in June, 1939, (4) indicating a high frequency of this phenomenon.

Varieties of wheat exhibit differential reactions to many hazards, such as cold, lodging, shattering, diseases, various insects, and others, so it comes as no surprise that certain varieties seem to differ in their reaction to hail stones. Neatby (7) reported varietal differences among spring wheat varieties observed in Alberta in 1938 and 1939 and among spring barley varieties in 1939. He reported a range in varietal reaction of 40 per cent for wheat and over 90 per cent for barley. Several investigators have studied the effects of simulated hail damage. Among these are Klages (6) on flax, Eldredge (3) on small grains, Dungan (1), Eldredge (2) and Hume and Franzke (5) on corn. These latter investigators have shown the important relative effects of hail coming at different stages in the development of the crop but do not emphasize varietal reaction.

On June 7, 1939, in late afternoon, a hail storm, extending over an area 2 miles wide and 20 miles long, inflicted variable damage to crops northwest of Manhattan, Kansas.* Included in its path were the varietal test plats of winter wheat at the Agronomy Farm and the plant breeding nursery. Gross estimates of the damage to wheat were placed at 75 per cent on the Agronomy Farm and 25 per cent in the nursery. Careful estimates made later showed average varietal differences in the plats of 42.0 per cent in amount of broken straw and 14.0 per cent in quantity of grain beaten from the heads. Similar contrasts were apparent in the nursery. Representative differences are shown in Fig. 1. A few detailed results seem worthy of presentation.

MATERIAL AND METHODS

Twenty-seven varieties and strains were grown in triplicated 1/40 acre plats systematically arranged in two belts, the first containing two-thirds of the plats with the others across a 30-foot roadway. Stands were uniform. In the plant breeding rod row nursery, 146 varieties and strains, including check plats were grown in triplicated 3-row blocks. Stands were somewhat irregular due to dry soil during the fall and the irregularity persisted to a certain extent throughout the season, making it difficult to take accurate notes on height and

[1]Contribution No. 338 Department of Agronomy, Kansas Agricultural Experiment Station, Manhattan.

date of maturity. A similar nursery, except that the rows were only eight feet long, contained 293 entries. Estimates of hail damage were made on all of this material.

FIG. 1.—General view of hail damage to Tenmarq (left) and Nebred (right) winter wheat, Agronomy Farm, Manhattan, Kansas. The average amounts of broken straw for these varieties were 95 and 62 percent respectively.

The estimates of varieties grown in plats were made after random samples from plats of Quivira, Tenmarq, Kawvale, and Cheyenne were studied critically for the number of broken straws and grains beaten from the heads as a basis for assigning percentages. Four men* made independent estimates on each farm plat and rechecked all cases where differences of more than 5 per cent existed. Estimates in the nursery were made by the writer with a helper to record the readings thus eliminating bias in assigning percentages for the different replicates.

All farm plats were harvested with the ordinary grain binder leaving about four inches of stubble. Nursery rows were cut by hand as close as possible to the ground. In both harvesting methods a large number of heads were lost in handling.

Small samples of Turkey and Tenmarq, having all broken straw, and comparable samples of these varieties with unbroken straw were secured for grain studies.

*James A. Blodgett and Alva L. Finker, graduate research assistants, Department of Agronomy; J. E. Pallesen, Asst. Agric. Statistician, Bur Agr. Econ. U.S.D.A.; and the writer.

The hail storm of June 7 came about two to three weeks after the varieties had headed.

RESULTS FROM FARM PLATS

The data given in Table 1 show the date of heading, hail damage, yield, and test weight for each of the varieties grown in farm plats. The average percentage of broken straw ranged from 53 for Cheyenne to 95 for Tenmarq. The amount of grain beaten from the heads showed an average range of 14 per cent, being greatest for a strain of Kawvale x Tenmarq (Ks. 2735) and least for Tenmarq. The varieties seemed to have a specific reaction to the hail stones as illustrated in Fig. 1. In general, the Turkey group including Turkey 570, 570F, Kharkov and Oro were damaged similarly, with Nebred and Cheyenne reacting much the same also although damaged less. These six varieties showed less damage than the other 21 varieties compared. Varieties such as Kawvale and Fulcaster, known to shatter easily after reaching full maturity, as well as certain Kawvale derivatives, showed a tendency to lose more grain by the beating action of the hail. By analysis of variance it was determined that differences among the varieties were highly significant both

TABLE 1. Agronomic data for winter wheat varieties grown on Agronomy Farm, Manhattan, Kansas, 1939. (Average of triplicated 1/40-acre plats)

Variety	Kansas No.	C.I. No.	Dates: First heading May	Dates: Ripe June	Hail Damage: Broken culms %	Hail Damage: Shattered grain %	Yield Bu. per acre	Test weight lbs.
Early Blackhull	483	8856	10	9	84	12	17.84	58.8
Early Blackhull x Tenmarq	2739	11952	13	10	68	17	18.70	58.4
P 1066 x Prelude	2695	11590	14	14	68	12	19.34	57.8
Quivira	2628	8886	14	15	72	15	19.63	58.2
Tenmarq	514	6936	18	20	95	8	17.30	56.3
Oro x Tenmarq	2728	11672	16	16	75	18	16.91	56.9
Comanche	2729	11673	16	16	83	15	17.32	56.5
Oro x Tenmarq	2736	11727	17	19	83	15	15.51	56.6
Oro x Tenmarq	2738	11827	17	19	93	12	18.77	57.7
Pawnee	2723	11669	16	19	70	15	18.18	57.0
Kawvale x Tenmarq	2726	11950	16	19	88	13	18.45	55.4
Kawvale x Tenmarq	2727	11750	17	19	81	15	17.85	55.2
Kawvale x Tenmarq	2735	11951	16	19	82	22	12.82	55.4
Kanred x Marquis	2690	11589	17	19	70	17	16.47	57.8
Kawvale	2593	8180	19	20	80	20	13.63	54.7
Fulcaster	317	6471	19	20	82	17	14.47	56.3
Clarkan	505	8858	19	20	83	12	13.33	56.5
Harvest Queen	19	6199	19	21	83	12	12.69	54.6
Chiefkan	547	11754	17	20	82	10	16.26	57.7
Blackhull	343	6251	18	20	82	10	17.05	57.4
Kanred	2401	5146	19	20	80	8	18.35	55.5
Nebred	2719	10094	19	20	62	12	19.26	57.6
Turkey	570	1558	20	20	77	8	16.78	55.3
Turkey Farm	570F	1558	20	21	72	8	18.09	55.2
Kharkov	2591	1442	20	21	73	8	19.41	56.1
Cheyenne	2667	8885	20	21	53	13	19.49	56.6
Oro	495	8220	20	21	77	10	18.05	56.2

Plat data, except hail readings, were secured from H. H. Laude, Department of Agronomy.

for broken straw and shattered grain but that replication differences were non-significant. The standard error of the difference between any two variety means was found to be 6.97 per cent for broken straw and 3.13 per cent for shattered grain. Most of the varieties lie close to the means for all varieties of 78 and 13 per cent respectively for the two measures of damage but analyses show the varieties do not represent random variations.

Correlations between certain variables are shown in Table 2. From the data it is obvious that broken straw and shattering due to hail result in lower

yields but the degree of significance is slight. When these two factors are combined a larger value for "r", with greater significance, is obtained even though broken straw and shattered grain may not be significantly correlated.

The varieties damaged least were latest in maturity. Early Blackhull, the earliest strain in the test, was damaged more than the late varieties. However, Early Blackhull x Tenmarq, second earliest, had less straw damage than the mid-early group and is about equal to the best. No value for "r" was calculated but the correlation obviously would be of low order.

Three awnless varieties, Chiefkan, Clarkan, and Harvest Queen were not noticeably different in reaction from the average of beared forms of similar maturity.

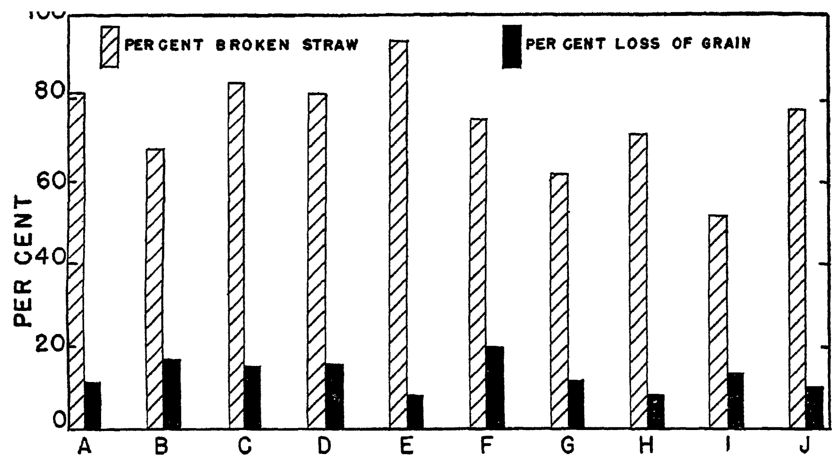

FIG. 2.—Average hail damage to varieties and hybrids of winter wheat, Agronomy Farm, Manhattan, Kansas, 1939. Strains are arranged in order of first heading (See Table 1). A—Early Blackhull; B—Early Blackhull x Tenmarq; C—average of four selections of Oro x Tenmarq; D—average of four selections of Kawvale x Tenmarq; E—Tenmarq; F—Kawvale; G—Nebred; H—Turkey; I—Cheyenne; J—Oro.

Figure 2 shows the relative damage by means of bar-graphs for several varieties and hybrids grown in plats.

RESULTS FROM THE NURSERY

Damage in the nursery averaged much less than that in the farm plat series, but the range was greater. In the rod row series, per cent broken straw ranged from 9 to 83, and the amount of grain beaten from the heads varied from 2 to 28 per cent. Damage was somewhat greater in the eight foot row series.

TABLE 2. Correlation coefficients showing the relation between variables for farm plat data.

	r value	S.E.*
Yield, bushels per acre and per cent broken straw	— 0.3450	± .1727
Yield, bushels per acre and per cent shattered grain	— 0.3470	± .1725
Yield, bushels per acre and per cent broken straw plus per cent shattered grain	— 0.4742	± .1520
Per cent broken straw and per cent shattered grain	— 0.1505	± .1916

*Standard error $= \frac{1 - r^2}{\sqrt{N-1}}$

TABLE 3. Summary of broken straw caused by hail, nursery strains of winter wheat, Manhattan, Kansas, 1939.

Group or hybrid	Class centers in per cent broken straw																				
	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52	55	58	61	64	67	73to83
All rod rows (RR)	5	16c*	20	28	24	9	16A	7	0	3	4	1	..	..	..	..	..	..	..	..	..
All 8 foot rows (9R8)	..	12	22	22	47c	25	34	20	14	18	6A	10	9	4	2	1	5	3	2	3	3
Marquillo x Oro (RR)	..	7	10	0	1	A	....	....	....	....	..	....	..	..	..	..	..	..	..	..	..
Marquillo x Oro (9R8)	..	12	16c	11c	9B	4	2D	1A	0	0	0	1	0	1	0	0	0	0	0	1	..
Cheyenne x Tenmarq (RR)	..	....	1	4B	4	1	1A	1	....	....	....	....	..	..	..	..	..	..	..	..	..
Kawvale x Marquillo (9R8)	..	....	1	2	7c	2F	1	1	0A	1	....	....	..	..	..	..	..	..	..	..	..
Kawvale x Cheyenne (9R8)	..	....	2	4	1c	3	3F	2	....	....	....	....	..	..	..	..	..	..	..	..	..
Marquillo x Tenmarq (RR)	..	....	....	1	2	1A	2	....	....	....	....	....	..	..	..	..	..	..	..	..	..
Marquillo x Tenmarq (9R8)	..	....	....	2c	7	6	8	8	5	2A	1	3	..	..	..	..	..	..	..	..	..
Kawvale x Tenmarq (RR)	..	....	....	2F	2	2	4	0	0A	0	2	....	..	..	..	..	..	..	..	..	..
Hope x Kawvale (9R8)	..	....	....	1	2cF	4	0	0	1	0	0	0A	0	1	1	0	1	1	..	..	..
Cheyenne x Tenmarq (9R8)	..	....	....	B	2	3	3	4	2	2	2	0	2A	..	..	..	..	..	..	..	..
Minturki x Marquillo (9R8)	..	....	....	....	4c	1	1	0E	0A	0	2	....	..	..	..	..	..	..	..	..	..
Kan.-H. Fed. x Tenmarq (9R8)	..	....	....	....	3c	0	0	1	0	1G	0	1	1	1	0A	1	0	0	1	1	3
Quivira x Tenmarq (9R8)	..	....	....	....	....	....	3	0	2	1	0H	0	0	0	1	A	..	..	..	..	..
Early Blkhl. x Tenmarq (9R8)	..	....	....	....	....	....	....	....	1	0	0	2I	..	..	..	A	..	..	..	..	..
Oro x Tenmarq (9R8)	..	....	....	....	....	....	....	....	....	D	..	....	..	..	..	A	2	1	1	1	..

*Letters indicate classification of parents and Checks grown nearest to the particular group:

A—Tenmarq; B—Cheyenne; C—Turkey; D—Oro; E—Minturki; F—Kawvale; G—Kan. x Hd. Fed.; H—Quivira;

I—Early Blackhull

Frequency distribution of damage to strains of wheat grown in the nursery are shown in tables 3 and 4. Strains of Marquillo x Oro showed most tolerance to the hail with Turkey and Cheyenne showing well also. Tenmarq showed heavy loss by breakage of straw but was exceeded by many strains. Loss from shattering was evident in Kawvale, certain Kawvale hybrids, Iobred and others.

Among the hybrid strains Marquillo x Oro and Cheyenne x Tenmarq forms showed tolerance to hail as contrasted with Oro x Tenmarq, Marquillo x Tenmarq, and certain strains of. Kanred—Hard Federation x Tenmarq. As a group, the Marquillo x Oro hybrids were outstanding in the nursery for re-

tance to grain loss also. Kawvale hybrids lost the most grain, while many of the others were within the range of the Tenmarq checks growing nearby. Marquillo, Hope, Cheyenne and Oro seemed to give shattering resistant hybrids when combined with other varieties. In the Hope x Kawvale group of 12 strains, two were marked "difficult to thresh" and one shattered about like Kawvale, indicating the distinct inheritance of this character. Resistance to breaking of straw was distinct in the hybrids involving Marquillo. When combined with Oro, strains apparently superior to Turkey and Cheyenne were secured, but when combined with Tenmarq, only a very few were as good as Turkey. Oro combined with Tenmarq gave strains more readily broken than Oro or Turkey with several strains injured more than Tenmarq. Strains from the Kanred-Hard Federation x Tenmarq cross showed evidence of transgressive segregation for straw tolerance to hail. The parents fall in the classes 37 and 52 percent respectively, while the strains available ranged from the tolerance of Turkey to 83 percent damage. No suitable early generation material was available to give an indication of genetic ratios. All of the strains may be considered fixed hybrids and were in F_7 or beyond.

TABLE 4. Summary of grain beaten from wheat heads by hail, nursery strains of winter wheat, Manhattan, Kansas, 1939.

Group or hybrid	Class center in per cent shattered grain									
	2	5	8	11	14	17	20	23	26	29
All rod rows (RR)	5	23C*	29A	33	23	13	4	1	2	1**
All 8 foot rows (9R8)	..	13	87C	96A	38	15	12	1	..	..
Marquillo x Oro (RR)	5	8	4	1A	....	....	....	..	..	..
Marquillo x Oro (9R8)	..	10	36D	12AC	....	....	....	..	..	..
Hope x Kawvale (9R8)	..	1	5	5AC	1	F	....	..	..	..
Cheyenne x Tenmarq (RR)	..	....	3	3AB	6	....	....	..	..	..
Cheyenne x Tenmarq (9R8)	..	....	2	12AB	6	....	....	..	..	..
Marquillo x Tenmarq (RR)	..	....	1	5A	....	....	....	..	..	..
Marquillo x Tenmarq (9R8)	..	....	25	17AC	....	....	....	..	..	..
Minturki x Marquillo (9R8)	..	....	5E	3AC	....	....	....	..	..	..
Kawvale x Cheyenne (9R8)	..	....	1	4C	7	F	3	..	..	..
Quivira x Tenmarq (9R8)	..	....	2	5A	H	....	....	..	..	..
Kawvale x Marquillo (9R8)	..	....	....	5AC	5	2	2F	1	..	..
Kawvale x Tenmarq (RR)	..	....	....	1A	2	7F	2	..	..	..
Kan.-H. Fed x Tenmarq (9R8)	..	....	....	6AC	6G	2	....	..	..	..
Oro x Tenmarq (9R8)	..	....	....	5AD	....	....	....	..	..	..
Early Blackhull x Tenmarq (9R8)	..	....	....	A	1	2I	....	..	..	..

*Letters indicate classification of parents and checks grown nearest to the particular group:

A—Tenmarq D—Oro G—Kanred x Hard Federation
B—Cheyenne E—Minturki H—Quivira
C—Turkey F—Kawvale I—Early Blackhull

**A selection of the cross of Kanred and Kawvale.

Statistical analyses on 32 varieties in one unit of the rod row series indicated highly significant differences among the varieties but no significance for replications. The standard error of the difference between any two variety means was 4.55 and 1.97 percent respectively, for broken straw and shattered grain.

Coefficients of correlation are shown in Table 5. Low yields were associated with high readings on hail damage although as in the farm plat series, correlations were of low order. Apparently several other factors influenced the yield more than hail alone. Straw breakage and grain shattering gave a non-significant correlation. Late strains were injured less on the average than earlier strains although the coefficient was low.

Since a significant correlation was obtained between maturity and damage, it was thought worthwhile to analyze as a group those varieties from the rod

rows which headed on the same day and varied in ripening by only one day. Thirty-four varieties used showed highly significant differences for both broken straw and shattered grain with standard errors similar to the unselected group reported above thus reemphasizing the liklihood that wheat varieties also differ in reaction to hail by internal make-up that is not a direct outgrowth of stage of development.

PLUMPNESS OF GRAIN

Test weights per bushel were slightly below average for most varieties although a few varieties had better test weight than average for the past several years. Grain samples, however, showed more variation in plumpness of individual kernels than usual. Seeds ranged from badly shriveled to well formed plump kernels. Some of the kernels in the heads appeared to be injured where struck by hail even though they were not beaten out. Probably the most shriveling resulted in heads on broken straws where trans-

TABLE 5. Correlation coefficients for hail damage to winter wheat, rod row nursery, Manhattan, 1939.

Variables	No. of Strains	r Value	S.E.*
Yield and per cent broken straw	32	— 0.4764	± 0.1388
Yield and per cent shattered grain	32	— 0.1922	± 0.1729
Yield and per cent broken straw plus per cent shattered grain	32	— 0.5013	± 0.1345
Per cent broken straw and per cent shattered grain	32	+ 0.0425	± 0.1793
Date headed and broken straw plus shattered grain	132	— 0.3144	± 0.0787

$$^{*}\text{S. E.} = \frac{1 - r^2}{\sqrt{N - 1}}$$

location of food and water through the culm was inhibited. Many heads fell to the ground but of those remaining attached and actually harvested, certain heads died a few days after the storm, others developed slowly and imperfectly while some heads appeared to continue development about as well as heads on unbroken culms. This, of course, gave extreme variability in kernel plumpness.

Heads of Turkey and Tenmarq were harvested from upright and broken straws, threshed separately and kernel plumpness compared. The weight of 1000 kernels for the four samples was as follows:

Tenmarq—heads broken over	25.32 grams
Tenmarq—heads upright	28.70 grams
Turkey—heads broken over	25.57 grams
Turkey—heads upright	27.35 grams

Thus in each case grain from upright heads was heavier as would be expected. The comparative weights show that kernels from broken straws were 11.8 percent lighter in the case of Tenmarq and 9.2 percent lighter for Turkey. Therefore, filling appeared to be about 90 percent of normal in heads on broken straws. The weight of 25 cc was also taken on each of the above four samples and test weight in pounds per bushel was calculated. Grain from broken straws showed 3.8 pounds lower weight per bushel for Tenmarq and 2.1 pounds lower for Turkey.

These determinations point out the possibility of salvaging considerable grain from broken straws under some conditions, especially when damage to the straw does not seriously reduce translocation but they also indicate

that lower test weight is likely to result which will reduce the unit market value of the crop and thereby accentuate economic losses due to lower yield and greater harvesting expense.

DISCUSSION

This analysis of reaction to hail shows that varieties differed significantly under the conditions prevailing in 1939 at Manhattan. Several factors appear to cause variation in hail loss among which are natural tendency to shatter, character of the straw, stage of growth of the plants, recovery of the plants, salvage of a damaged crop, size of hail stones and angle of impact of the stones. One of the most clean-cut observations was the greater loss of grain among those varieties, such as Kawvale, which shatter easily. It was interesting that such a characteristic should be expressed nearly two weeks before full maturity. The straw varies in size, stiffness, and resilience for the different varieties. It is probable that straw breakage may be a function of the resilience of the straw, and impact of the hail stones. Large brittle erect straw might be broken badly by stones hitting the straw at an angle but might escape severe injury if small stones fell or the wind was not blowing at the time the hail occurred. Small straw may be more resilient than the larger straw. Furthermore, fiber content and general toughness of straw probably are related to this phenomenon. It is also probable that resilience changes progressively throughout the life of the plant. If all or part of these variables exist, then it would be expected that the relative ranking of several varieties might change somewhat in case they were subjected to hail under different environments and at different stages of maturity. The writer has examined unpublished data from several experiment stations and finds considerable variation in rank of varieties for broken straw but remarkably good agreement in amount of grain beaten from the heads. Recovery of the plants following hail may vary greatly in different varieties and environments, a fact amply demonstrated on wheat by Eldredge (3). More data are needed, however, to show why varieties differ in reaction to hail stones.

While many factors may modify the effect a hail storm may have, it seems clear that varietal reaction must be considered as a real variable. Whether wheat breeding objectives should include hail resistance may be questioned, but breeders should favor strains for advancement that have survived a hail storm relatively better than others.

SUMMARY

A hail storm partially destroyed the plantings of winter wheat on the experiment station at Manhattan, Kansas, June 7, 1939, approximately two weeks before most varieties were ripe.

Differential reaction to the hail was noted among 27 varieties and hybrids in triplicated 1/40-acre plats and among over 400 varieties and hybrids in the triplicated nursery plats of three rows each. Readings of broken straw and shattered grain were taken on each replication for all of these strains.

Analysis of variance showed highly significant differences among the strains for broken straw and shattered grain in the plats and nursery but replication differences were non-significant. Varieties with a natural tendency to shatter were shattered badly by the hail.

Correlation coefficients were calculated which showed a negative relationship of hail damage to yield and maturity. Although late strains were damaged less than early strains, further analysis showed that wheat varieties maturing at the same time differed significantly in reaction to the hail.

LITERATURE CITED

1. DUNGAN, G. H. Effect of hail injury on the development of the corn plant. Am. Soc. Agron. Jour. 20:51-54. 1928.
2. ELDREDGE, JOHN C. The effect of injury in imitation of hail damage on the development of the corn plant. Iowa Agr. Exp. Sta. Res. Bull. 185. 1935.
3. ————. The effect of injury in imitation of hail damage on the development of small grain. Iowa Agr. Exp. Sta. Res. Bull. 219. 1937.
4. FLORA, S. D. Climatological data; Kansas section. U. S. Weather Bu. 53 (No. 6): 1939.
5. HUME, A. N. and FRANZKE, C. The effects of certain injuries to leaves of corn plants upon weights of grain produced. Am. Soc. Agron. Jour. 21:1156-1164. 1929.
6. KLAGES, K. H. W. The effects of simulated hail injuries on flax. Am. Soc. Agron. Jour. 25:534-540. 1933.
7. NEATBY, K. W. Varietal differences in wheat and barley with respect to hail damage. The Press Bulletin 25 (No. 1): 1-2, 1940.
8. SMITH, J. W. Damage to crops by weather. U. S. Mo. Weather Rev. 48:446, 1920.

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Aplectrum Spicatum in a Kansas Woodland

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None of our herbaria of Kansas plants contains *Aplectrum spicatum* (*A. hyemale* Nutt.) and the opinion of botanists has been that it is not native here, its westward extension in the North Central States being supposed to be in southeastern and central Missouri. Now, however, we can record its presence in Leavenworth County, Kansas, in a wooded cove in the low bluff facing the Missouri river where it flows past the Military Reservation. We were made aware of its presence by Mr. J. V. Kelly, Leavenworth business man, who grew up there, and since the days of his youth has found recreation in excursions through the woods and fields of his county, observing especially events in bird and plant life through the seasons. And so it happened that a small society of this *Aplectrum,* hidden in a recess of the bluffs did not escape the eye of the young naturalist of thirty years ago, who noticed that a single leaf and a single inflorescence were all that a plant showed of itself, while keeping concealed below ground a curious Siamese-twin pair of corms. We are happy to express here our gratitude to Mr. Kelly for supplying us with the specimens used in this study.

Although the extreme western occurrence of this species in our section of the continent now appears to be in Leavenworth County, Kansas, it occurs on our east coast from Vermont to Georgia, and in Canada from Ontario to Saskatchewan, and on our west coast in California and Oregon. While ranging thus widely its rare occurrence would seem to indicate that the various environmental factors necessary to its success are rarely concurrent.

The purpose of the present paper is to show how it is faring in its only known Kansas habitat. We begin by showing photographs of two corm pairs (Fig. 1 and 2, Plate I) dug up April 24, 1941—one member of each pair bearing a leaf, and a third pair (Fig. 3, Plate I), dug up at the end of May 1941 when the leaf-bearing corm was bearing also a long-peduncled inflorescence,—the leaf, however, being now sloughed away and the inflorescence cut off so that only a basal segment of the peduncle remains.

The members of a corm pair are related to each other as parent, A, and offspring, B, the latter bearing the leaf and inflorescence of the current year, the former having performed that function the previous year. Comparing Figs. 1 and 2 with Fig. 3 it will be seen that both members of a pair of corms enlarge considerably between the last of April and the last of May, the offspring corm still being in process of growth and the parent corm swelling, due to imbibition of water by the residue of mucilage that it still contains after contributing from its original reserves of starch, mucilage, etc. to the production of the crop of seeds it bore the previous summer as well as to the growth of the offspring corm. The water relationship of the parent to the offspring corm is noteworthy. More or less saturated mucilage is itself a reserve of water and the parent corm would be delivering water to its off-

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spring whenever the latter were demanding more water than its own roots could supply. This lack of water might often happen in the winter when the low temperature makes absorption of water by roots difficult. Since the evergreen leaf would be evaporating water through the winter, the reserve of water held in the mucilage of the parent corm might well become at times a matter of vital importance. And, again, the more the mucilage in both corms lost water, the harder it would pull to restrain the loss, and in so doing it would act as a brake on transpiration. Thus the mucilage is doubly useful in being, like starch, a carbohydrate food, and in the water relationship mentioned above; and the parent corm in its second summer is still a useful member of a parent-offspring corm pair. Our specimens have not had parent corms living into grandparentage, though MacDougal (7) reports the occurrence sometimes of a string of corms beginning with a grandparent containing still unexhausted reserves.

Referring to Plate I, Fig. 3, B, it is to be seen that this corm, now blooming towards the end of May, is putting forth an adventitious rhizome from the left side. This offshoot is destined to grow longer and produce a corm at its terminus that will be bearing a leaf soon in the summer, and will be blooming towards the end of May of the following year. The rhizome offshoot connecting corms A and B in these figures is to be seen in all but Fig. 1 where it is so short that the roots obscure it.

The relationship between corms, rhizome offshoots, and the roots, and the stages in the production of the corms by the rhizome offshoots are shown by the diagrammatic drawings A, B, and C, Plate II. In C the diagrams a, b, c, and d, and at a in B show how the growing point of a rhizome offshoot emerges laterally from the middle internode of corm B and proceeds to form a series of internodes, advancing through stages b, c, and d, to the production of a juvenile corm by the enlargement of internodes 4, 5, and 6. Internode 3 is destined to produce the roots. The number of internodes may vary slightly between different plants, and nowhere on the plant excepting the rhizome internode subtending the base of the corm (in this instance, internode 3) have we found roots.

After the formation of internode 6 a basal ring of cells of the growing point produces a leaf, consisting of a tubular stalk and an expanded blade, but the apical part of the growing point, now surmounting the node above internode 6 and surrounded by the circular base of the leaf, terminates its activity by forming a slight elevation of the stem above the insertion of the leaf (Fig. E, b Plate II).

Corm A of our photographs, and represented in our diagram, bloomed in late May, 1940, and was then beginning to produce corm B in the manner shown in diagrams a, b, c, and d, of C. The leaf of B appeared above the ground in July, or late June, 1940. The leaf lived on through the winter and in April, 1941, appeared as in Figs. 1 and 2, Plate I, and as shown diagrammatically in Plate II. This leaf is the plant's only photosynthesizing or food-making foliage-leaf, but the plant has three other types of leaves, namely, the thin tunics enwrapping the corm and extending to various distances around the stalk of the foliage-leaf; the thin, brownish, frayed sheaths around the bases of the internodes of the rhizome offshoot; and finally, the bract-like leaves borne by the peduncle.

Aberrances in the development and behavior of the corms sometimes appear. Plate III shows at the time of blooming two pairs of corms with noteworthy irregularities. The offspring corm of the right-hand pair has its bottom segment extending high up on the right, and near its upper limit it is giving off a rhizome offshoot, although these offshoots almost invariably spring from the middle section of the corm, as shown by the parent corms in Plate I. The peduncle, however, following the rule in this species, originates adventitiously from the upper internode some distance below the base of the foliage-leaf. An extreme case of separation of the peduncle from the apex of the corm is shown by the offspring corm of the left-hand pair of Plate III. Three segments of the long peduncle from this corm are shown, the top segment bearing the flowers. The leaf-blade of this corm has broken away at the abscission layer and a slender stem representing an abnormal extension of the axis has come up through the unusually slender leaf-sheath.

We have seen that a corm consists principally of three much enlarged internodes, and now we will look at it as a reservoir of food and water—a storehouse of the products of the foliage leaf and of the booty which the roots take from the mycorhizal fungi entering into them from the humus-rich soil characteristic of the orchid's habitat—an interesting episode in the life of *Aplectrum* and other orchids which will receive attention later in this paper.

Cross sections through the internodes of the corm show narrow vascular bundles scattered through thin-walled parenchyma tissues composing the bulk of the corm. These tissues are of two kinds: a globular network of relatively small starch-filled cells whose fabric extends in all directions; and, occupying the meshes of this network, a tissue of larger cells filled with mucilage, with occasional bundles of needle-shaped calcium oxalate crystals. It will be seen in Figs. 9 and 10, Plate IV, that the cells of the starch-filled tissues have their long axis oriented towards the vascular bundles so as to facilitate interchange of materials between the two systems; and we may assume that the functions of the mucilage-bearing tissue are also indirectly served by this arrangement.

Comparing sections of the parent with those of the offspring corm we find that the parent has given up most of its starch, its mucilage cells are shrunken and its calcium oxalate crystals are diminished (Figs. 9 and 10, Plate IV).

The only chemical analysis of *Aplectrum* bulbs that we have found was made by Paschke (9). Air-dried corms were found to contain water, 13.43%; mucilage, 29.65%; starch 55.92%; albumin, a trace. In this analysis the calcium oxalate crystals, seen with the microscope to occur frequently in the peripheral mucilage-bearing tissue especially, are not accounted for; and the full amount of organic nitrogenous stuff could not have been separated out, judging from the fact that the dried and powdered tubers of orchids, known in the drug trade as salep, is reported to contain 5% protein.

The parent corm, A, in producing its crop of seeds and nourishing its offspring corm, B, becomes depleted of its reserve materials and shrunken, as seen to good advantage in Fig. 2, Plate I. The marked increase in the size of the corms between the last of April and the last of May (compare Fig. 2 with Fig. 3, Plate I) is evidently in consequence of continued growth of corm B and an increase in absorption of water by both corms as the soil became warmer with the advance of spring.

Some features of the remarkable *Aplectrum* leaf should now be examined, a leaf that endures and functions for about ten months, through the cold and drought of winter and the heat and drought of summer, even maintaining its annual cycle through the recent excessive drought of several years duration. When in July or late June the leaf appears above the ground, upright, ribbed and stiff, cross sections of the blade (Fig. 7, Plate IV) show that the stiffness is due mostly to the strands of elongate sclerenchyma cells that are found both above and below the vascular bundles of the longitudinal veins running only 0.3 mm. apart, through the length of the blade; and these veins are bound together by lateral branches at intervals of about 2 mm. Over all is stretched an epidermis with a thickened, waterproofed outer wall (Fig. 7, Plate IV). Such a venation system makes a strong framework for that most delicate and vital chlorenchyma tissue filling its meshes with 6 to 7 tangential layers of cells (layers parallel to the two surfaces),—an upper, definitely palisade layer, and succeeding layers of intergrading palisade and spongy character. Providing intake and outgo of gases for the chlorenchyma we find 49 stomata per square mm. in the upper and 78 per square mm. in the lower epidermis; or the strip of chlorenchyma lying between two parallel veins of average distance apart would be served by approximately 38 stomata per running mm. Here we have a system organized for efficient mass production. The transporting system of the vascular bundles has a short, straightway course from the roots through the corm and leaf; and the average distance raw materials and synthesized products would need to travel in the chlorenchyma from and to the pipelines of the veins would approximate the thickness of only five leaves of these *Transactions*. Certain it is that the sole leaf of a plant should be organized for utmost efficiency.

We bear in mind, however, that orchids in general have a symbiotic relationship with fungi which live in the complex humus of the soil and digest and assimilate its dead vegetable components, and which also apply themselves to the surfaces, or penetrate into, the root cells of higher plants and exchange nutrient substances with them. This association of fungus and root is called mycorhiza, from the Greek words, *mykes*=mushroom or fungus, and *rhiza*= root. Whether mature chlorophyllous orchids need this relationship, even those with only a single leaf, such as *Aplectrum*, has never been determined, but it is reasonable to suppose that they might be benefitted, since orchids without chlorophyll, such as *Corallorrhiza*, receive all their organic food from their fungus symbiont. The same fungus mycelium that penetrates orchid roots may also enter the roots of neighboring trees, complicating the question as to whether there is a mutuality of benefit among the symbionts. Obviously orchids without chlorophyll take more than they can possibly give and it would appear that *Aplectrum* does also, since MacDougal (l.c.) reports that his most robust specimens of *Aplectrum* were those whose roots were the most abundantly associated with fungus mycelium. However, orchids in their seedling condition are, under natural conditions of their habitats, unquestionably dependent on mycorhizal fungi to nurse them along until their roots and the first of their green leaves have developed. The seeds of orchids are a mere fraction of a millimeter in diameter; they are without endosperm and the embryo is a minute bit of undifferentiated tissue which in germinating has all the way to go with next to nothing to go on. Where the mycorhizal

fungus is not present the embryos make little growth and eventually come to nothing, but when the fungus is present its thread-like mycelium penetrates into the embryo through the suspensor and stimulates its growth by supplying it with nutriment obtained by digesting the fallen leaves, twigs, etc. from adjacent trees and possibly also furnishing it with organic substances absorbed from the roots of these trees. Various investigators have contributed to the discovery of these interesting facts; for instance, Bernard (1) showed that when the fungus was present in the embryo the latter enlarged, produced chlorophyll and absorbing hairs and finally roots, stem, and leaves. That supplying food to the embryo was the essential function of the fungus in this relationship, Bernard showed by getting successful growth of orchid embryos without the fungus when he supplied them with salep containing both carbohydrates and proteins. Knudson (5) secured excellent germination of seeds of *Cattleya, Laelia* and *Epidendrum* by growing them without the fungus in a sterilized medium containing the essential salts to which he added different percentages of sugar, 1 to 2 per cent giving the best results; and later by the same methods he was equally successful in growing, without the fungus, species belonging to various other orchid genera (6).

The anatomy of *Aplectrum spicatum* is given in considerable detail by MacDougal (1.c), and he shows the occurrence of a mycorhizal fungus in the root-hairs, roots, and rhizome offshoots, the mycelium having come through the humus from the mycorhiza of adjacent trees. We find mycelium present in our specimens of *Aplectrum* also (Figs. 13 and 14, Plate IV), as is now to be expected in a member of the orchid family, since Wahrlich (11) demonstrated its constant occurrence in various European species and about 500 exotic species of the orchid family.

The fungus was not found in the corm, leaf, and inflorescence of *Aplectrum,* probably due to fungicidal secretions in the corm, such as Bernard (2) discovered in the tuber-bearing genera, *Orchis, Ophrys,* and others in the group *Ophrydeae.*

It appears doubtful from the summation of evidence by Rayner (10) that chlorophyllous orchids must have association with mycorhizal fungi beyond the completion of their germination and the appearance of chlorophyll in their first leaves, and it is doubtful also that the mycorhizal fungi need union with orchids for complete living.

How the fungus symbiont acquired the habit of nursing orchid seedlings, which without this service would come to nothing, could probably not be told without acquaintance with the progress of evolution of the orchid family, which, according to Hutchinson, (4) comes from some offshoot of the Liliales, a group noted for a distinct and usually copious endosperm and radially symmetric (actinomorphic) flowers. But the multitude of intermediate stages that must have come and gone before the orchids appeared, with their radially asymmetric (zygomorphic) flowers, consolidation of vestigial with other parts, as worked out by Darwin (3), vanished endosperm, and embryo degenerated to a minute aggregation of undifferentiated cells, rendering the seeds incapable of germination without union with other forms of plants quite unlike themselves in character, are only to be imagined. Thus, for one thing, we may imagine that mutations leading to the deterioration of the endosperm and embryo were linked with others giving rise to a chemotropic attraction of the

embryo for the mycelium of certain fungi, and so preserving the orchids from extinction while on their way to becoming one of the most wonderful of plant groups.

The reduction in size of the seeds of orchids was accompanied by great increase in number—several thousand per capsule in some genera, to nearly two million per capsule in *Maxillaria*. Darwin (l.c., p. 277) estimated the number of seeds in a capsule of *Orchis maculata* to be 62,000, making the approximate number for the entire plant 186,300. If all went well with the viable seeds in each capsule an acre of ground would be covered by the offspring of a single plant, and the great grandchildren of such a plant would suffice to "clothe with one uniform green carpet the entire surface of the land throughout the globe."

The seeds of orchids are light enough to be dispersed over a continent by the wind, and it seems hardly possible that *Aplectrum* seeds have not from time to time been widely dispersed in Kansas, especially in its eastern part. Yet we must recall that although the number of known species of orchids is immense—about 15,000 at the present time, they are sparsely distributed within their range, and when colonies occur the number of individuals comprising them is usually few. This situation would seem to be due primarily to the mischances confronting the delicate embryos. They would quickly dry up in the early stages of germination if overtaken by drying winds or drought, and they would perish if the fungus necessary to their growth were absent or held back by unfavorable environmental conditions. Not the orchid alone but also its symbiont must have its own particular needs fulfilled; and the chances of the concurrence and permanence of conditions necessary to both symbionts are precarious in Kansas woodlands. However, when the corms, tuberous rhizomes or tuberous roots of our native orchids have once established themselves in the substratum they show a high degree of persistence, even when transplanted into gardens after their flowering season is over, care being given to preservation of the underground parts and to providing a place in the garden where the conditions are reasonably similar to those of the natural habitat. This is the common experience with *Cypripedium* in eastern Kansas. Our rarest orchid, too, has been successfully transplanted by Mr. Kelly. Orput (8) also reports from wide observation that "*Aplectrum hyemale*, found but rarely, is easy of culture and transplanting, owing to its having bulbs like many exotic species."

LITERATURE CITED

1. Bernard, Noel. L'evolution dans la symbiose. L'orchidées et leur champignons commensaux. Ann. Sci. Nat. Bot. 9 me ser. 9:1-92. 1909
2. ———. Sur la fonction fongicide des bulbes d'Ophrydées. Ann. Sci. Nat. Bot. 9 me ser. 14: 235. 1911
3. Darwin, Charles. The various contrivances by which Orchids are fertilized by Insects. 2nd ed. Chap. VIII. John Murray, London 1877.
4. Hutchinson, J. The Families of Flowering Plants. II. Monocotyledons. pp. 7, 11, 15, 166, 167. Macmillan & Co. London 1927.
5. Knudson, Lewis. Nonsymbiotic germination of orchid seeds. Bot. Gaz. 73: 1-25. 1922
6. ———. Further observations on nonsymbiotic germination of orchid seeds. Bot. Gaz. 77:212-219. 1924.
7. MacDougal, Daniel Trembly. Symbiotic parasitism. Ann. Bot 13: 1-49. 1899

8. ORPUT, E. O. Hardy orchids. The Standard Cyclopedia of Horticulture by L. H. Bailey. 3 Vol. ed. 2:2398. The Macmillan Co., New York. 1935.
9. TASCHKE, H. Ueber zwei schleimliefernde Droguen. Pharmaceutische Post XIII. No. 16. 1880.
10. RAYNER, M. C. Mycorrhiza, an Account of Non-pathogenic Infection by Fungi in Vascular Plants and Bryophytes. p. 202. Weldon and Wesley, London 1927
11. WAHRLICH, W. Beitrag zur Kenntniss der Orchideen-wurzelpilze. Bot. Zeit. 44: 480. 1886

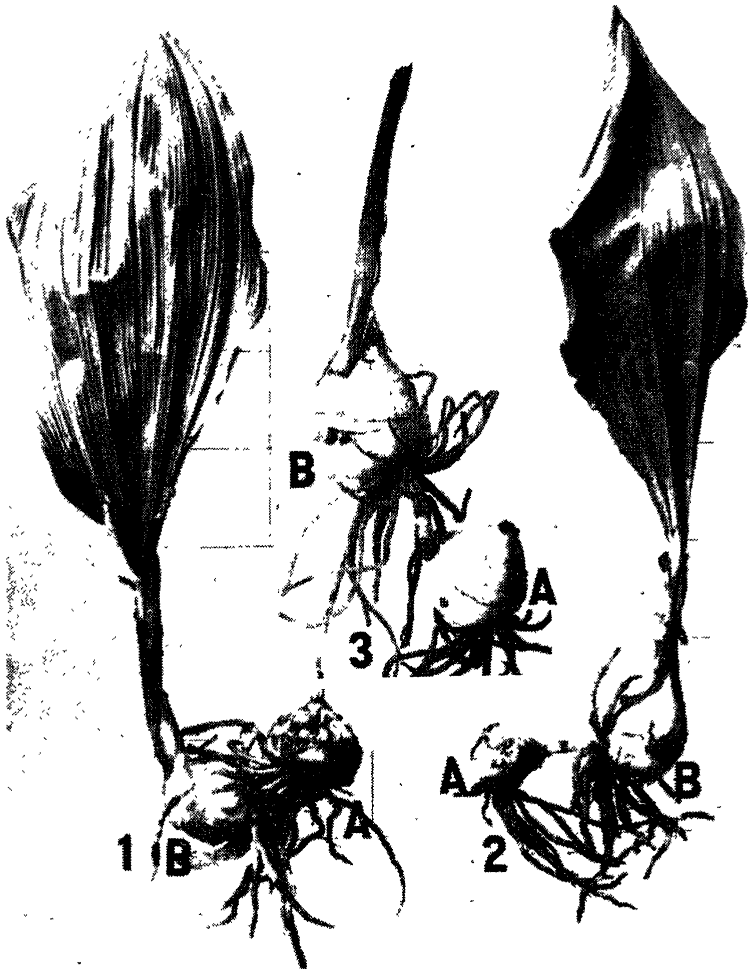

PLATE I

Fig.

1. *Aplectrum spicatum* parent corm and mature offspring, with presentation of upper side of the leaf, April 24.
2. Another corm pair showing rhizome offshoot connecting the two corms, and presentation of the under side of the leaf, April 24.
3. Corm pair towards the end of May when the offspring corm is in bloom; the lower portion of the peduncle only is shown and we see the peduncle originates in the uppermost internode of the corm below the nodal insertion of the leaf. The leaf has sloughed away by means of the abscission layer at the base of the leaf-stalk.

The squares represent square inches.

PLATE II

Numbers indicate the internodes.

A. Parent corm, showing internodes and manner of attachment to offspring corm. X 1.

B. Offspring corm, showing: a, beginning of rhizome offshoot for producing new corm; b, cross section of leaf-stalk, which is a closed leaf-sheath; c, cross section of opened leaf-sheath; d, abscission layer between leaf-sheath and blade. X 1.

C. Steps in the development of a new corm from the parent corm.

D. Detail drawing of the abscission layer of B, d. X 75.

E. (a) Abscission layer at the base of the leaf-stalk.
   (b) Termination of stem axis at apex of offspring corm B, enclosed by base of leaf-stalk. X 6.

F. Tangential section thru the abscission layer B, d, showing its relation to the veins. X 25.

G. Termination of stem axis of parent corm after abscission of leaf-sheath. X 6.

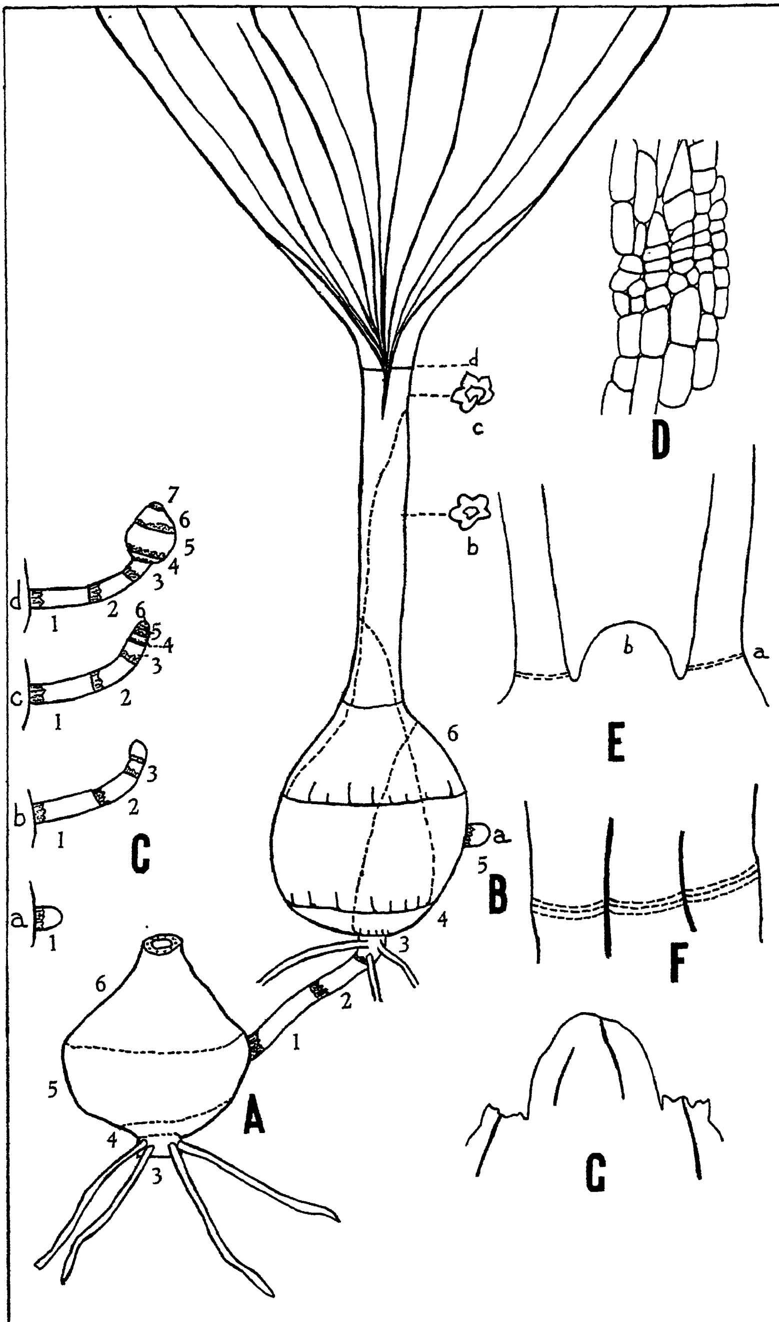
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PLATE III

Time, end of May.

Two corm pairs with some aberrances are shown. The offspring corm of the right-hand pair shows its basal internode asymmetrically developed, rising high on the right side, and at its highest part giving off a rhizome offshoot. The rule is that the rhizome offshoots spring from the middle internode of the corm, as shown in the parent corms of Figs. 2 and 3, Plate I.

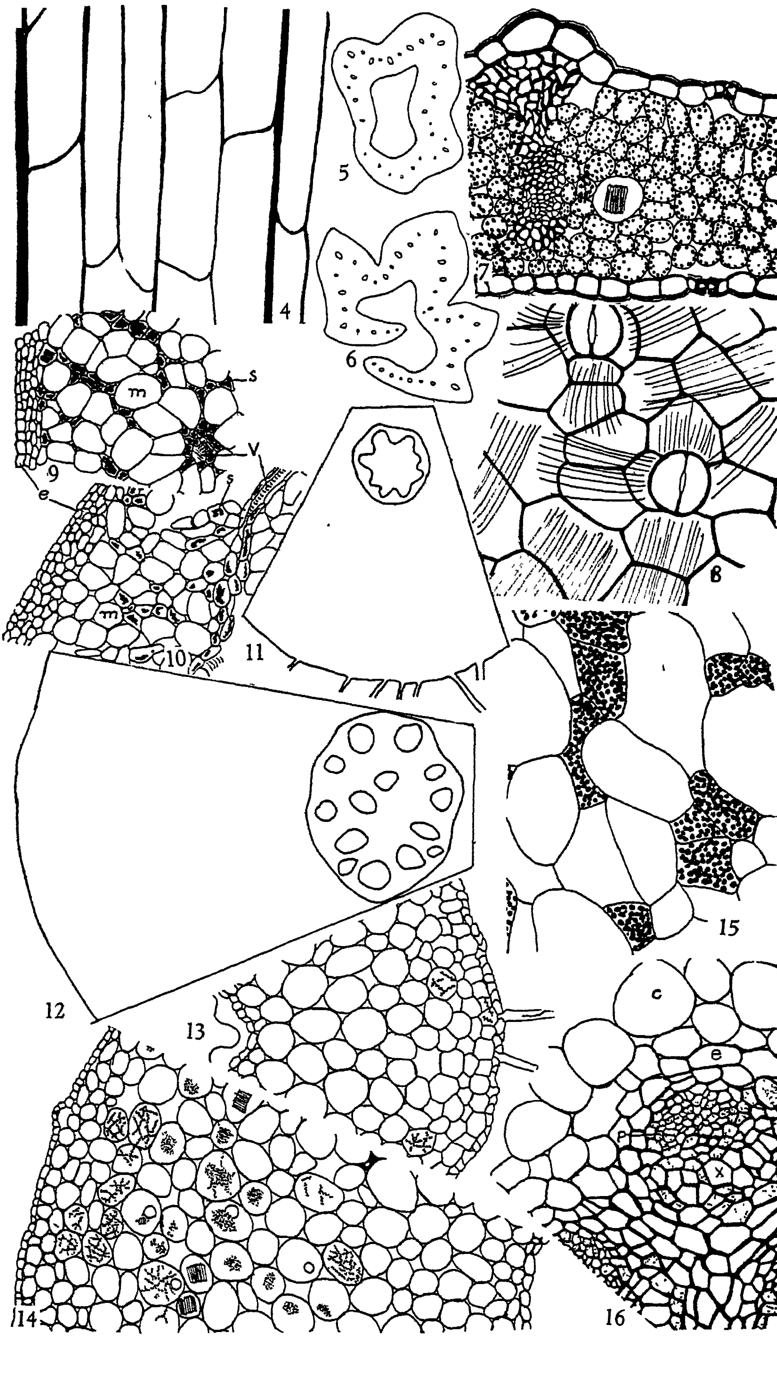
The offspring corm of the left-hand pair shows the peduncle abnormally distant from the corm apex where the leaf originates, presenting in a striking manner the adventitious origin of the peduncle. The asymmetrical development of the corm is very evident, the side to the right of the axis being much larger than the opposite side, and the peduncle emerges from the side having the most abundant reserves of food. The blade of the leaf of this corm has disintegrated; the leaf-stalk is unusually slender, and extending out of it is a slender stem, a feeble attempt at the continuation of the stem axis, showing how the peduncle would come out if it were a continuation of the axis or from the axil of the foliage-leaf, instead of arising adventitiously, as it does, below the leaf. In order to show all of the peduncle within the limits of the photograph it has been cut into four segments, the lowest being attached to the corm and the uppermost bearing the inflorescence.

The detached leaf-blade in the right half of the photograph belongs to the offspring corm to the right of it. The blade came away from the stalk at the upper abscission layer and the leaf-stalk has disintegrated down to the lower abscission layer. The leaf-blade itself is in process of disintegration.

As to the color of the parts of the inflorescence, the upper part of the peduncle and the inferior ovaries are green, the base of the perianth, excepting the labellum, is yellowish-green inside and outside, while the labellum and the column are ochroleucous, purple dotted. The thickened fibrous roots are beset with root-hairs from near the tip to the base, but they were so much wilted that they do not come out in the photograph. The squares demarked by fine lines represent square inches.

PLATE IV

Fig.
4. Detail in leaf venation. X 18.5.
5. Cross section of closed portion of leaf-stalk. X 5.
6. Cross section of open portion of leaf-stalk. X 5.
7. Leaf cross section. X 125.
8. Epidermis, surface view. X 260.
9. Cross section from offspring corm. X 25.
   e, epidermis; m, mucilage cell; s, starch cell; v, vascular bundle surrounded by starch cells.
10. Cross section from parent corm. X 25. Letters as in Fig. 9.
11. Diagram of root showing stele. X 35.
12. Diagram of rhizome offshoot showing stele. X 35.
13. Cross section of root showing some cells of the cortex with mycorhiza. X 51.5.
14. *Cross section of rhizome offshoot showing many cells of the cortex with* mycorhiza and crystals. X 51.5.
15. Cells of the offspring corm showing starch-filled cells and mucilage cells. X 75.
16. Vascular bundles of rhizome offshoot. X 175. c, cortex; e endodermis; p, phloem; x, xylem.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Studies Pertaining to the Life History of Specularia Perfoliata (L.).A.DC., With Special Reference to Cleistogamy*

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A description of the morphology of the flowers of *Specularia perfoliata* has been given. (Trent, 1940). The aim of this investigation was to make a comparative study of megasporogenesis, microsporogenesis, development of the embryo sac, and embryogeny in both the open and cleistogamous flowers of this species.

MATERIALS AND METHODS

The flowers used in this investigation were taken from plants grown for experimental purposes during the fall of 1938, and from plants growing in the field in the spring of 1939. Flowers were collected at regular and short intervals in order to get all the possible stages in the development of both the open and cleistogamous flowers. Navashin's solution and "Craf" were found to be the most satisfactory fixing fluids. Toluene and chloroform gave superior results to xylene in all procedures. The usual techniques were employed. The tissues were cut into serial sections of 10 microns in thickness. Heidenhain's iron-alum haematoxylin and Fleming's triple schedules were used on most preparations. For fresh preparations, the Belling technique and that employed by Barrett (1932) were used.

MEGASPOROGENESIS

The archesporial cell is first recognized situated just beneath the epidermal layer of cells soon after the young ovule becomes a slight protuberance upon the placenta (Fig. 1.). In some instances the cells adjacent to the archesporial cell show similar staining reactions, making differentiation difficult. The archesporial cell becomes directly the megaspore mother cell. (Fig. 2.). The megaspore mother cell becomes elongated, and after two successive meiotic divisions, produces a linear tetrad of megaspores. (Figs. 3, 4, 5.). The chalazal megaspore becomes the functional one and rapidly enlarges in all directions, but especially in the direction of the micropyle. (Fig. 6.). By means of this encroachment upon the lower megaspores, they become crushed The third megaspore from the micropylar end is the first to be destroyed, and then the next lower ones in order. (Figs. 6, 7.). The crushed megaspores are represented in the drawings as undifferentiated deeply stained masses.

THE NUCELLUS

The nucellar layer is present and perceptible from the time of differentiation of the archesporial cell into the megaspore mother cell (Fig. 2.) and is

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The author wishes to thank Dr. Glenn W. Blaydes for his helpful and encouraging attitude during the progress of this investigation. The encouragement, generosity, and untiring patience of the late Professor John Henry Schaffner during the early stages of the work are vividly recalled. Thanks are also due Mr. S. A. Mannoni for his assistance in making the drawings.

observed intact to the end of megaspore formation (Figs. 3, 4, 5.). The nucellar layer consists of cells one layer in thickness. At first these cells are about the same shape and size as those of the adjacent tissue cells but upon elongation of the megaspore mother cell, they become stretched and are later destroyed during the growth of the functional megaspore. (Figs. 6, 7.). Remnants of the nucellar layer are observed as far as the 4-nucleate embryo sac. (Fig. 9.). The remnants of the nucellus is recognized during these stages as deeply stained undifferentiated material pushed against the wall of the embryo sac.

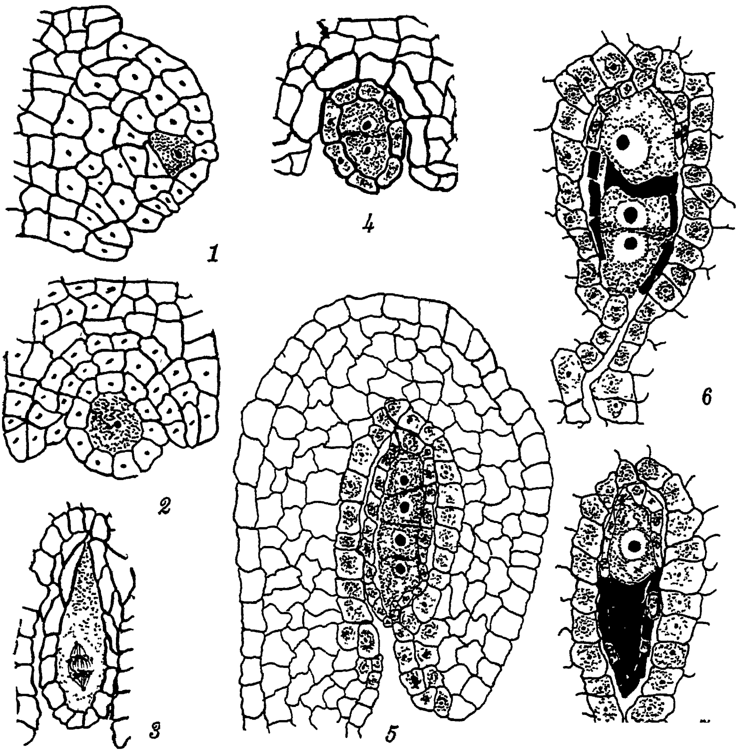


PLATE I*, FIGURES 1-7

1. Very young ovule showing archesporial cell. (From open flower.)
2. Megaspore mother cell and early stage in formation of integument. (From open flower.)
3. Megaspore mother cell in reduction division. (From open flower.)
4. Megaspores following first division of megaspore mother cell. (From open flower.)
5. Complete tetrad of megaspores. (From cleistogamous flower.)
6. Chalazal megaspore beginning to enlarge. The third megaspore from the micropylar end is first one destroyed. Nucellar cells around lower megaspores crushed. (From cleistogamous flower.)
7. Three megaspores disintegrating. (From cleistogamous flower.)

*All figures in plates are camera lucida drawings using a 6 X ocular and a Spencer 95 X objective unless otherwise indicated.

THE INTEGUMENT

After the nucellus has begun to turn at the tip, an integumentary tissue starts growing from its base. The integument soon envelops the megaspore mother cell, and attains its final position with reference to the nucellus and its contents, by the time of tetrad formation. (Fig. 5.). Only one integument is formed, which is a massive tissue constituting the greater part of the ovule.

THE OVULE

Shortly after the nucellus becomes prominent as a protuberance upon the placenta, the cells in the epidermal layer on one side of the nucellus begin anticlinal division more rapidly than on the other side, causing the ovule to bend. A typical anatropous ovule is the result. (Fig. 5) The ovule has attained its final position by the time of complete tetrad formation. The number of ovules in the ovulary is variable. Ovule counts have revealed from 31 to 180 ovules in cleistogamous flowers, and from 80 to 290 in the ovularies of open flowers.

THE EMBRYO SAC

The functional megaspore undergoes three rapid divisions in succession forming the 2-nucleate, 4-nucleate and 8-nucleate stages of the embryo sac. (Figs. 8, 9, 10.). Following the first division of the megaspore, the daughter nuclei move to the opposite ends of the rapidly elongating embryo sac, where one becomes the primary micropylar and the other the primary chalazal nucleus. (Fig. 8.). The second division gives rise to a pair of nuclei at each end of the embryo sac. (Fig. 9.), and a third division to a quartette of nuclei at each end of the embryo sac. (Fig. 10). The micropylar quartette of nuclei is composed of the egg apparatus and the polar nucleus. The chalazal quartette is composed of three antipodals and a polar nucleus. The two polar nuclei move away from their respective ends of the embryo sac and migrate toward the center, usually meeting an appreciable distance below the center, where fusion usually occurs, forming the fusion nucleus. (Fig. 11.).

The egg apparatus behaves in the usual manner, but the antipodals are ephemeral. Only a few preparations of the several hundreds made showed a good 3-nucleated antipodal apparatus as shown in Figure 11. The antipodals undergo a very rapid division giving rise to a multicellular haustorium which penetrates deeply into the integumentary tissue. (Figs. 12, 13). Figure 12 shows the beginning of the division of the antipodal nuclei and the formation of the haustorium. The haustorium has attained considerable size by the time the embryo sac is ready for fertilization. (Fig. 13.). Remnants of the haustorium are often present in the mature seeds. (Fig. 32.). Balicka-Iwanowaka (1899) observed chalazal haustoria in *Campanula rotundifolia,* and Barnes (1885) made a similar observation in *Campanula americana.*

TAPETUM

A very prominent tapetum of one layer of cells in thickness completely surrounds the embryo sac except at the micropylar end. Barnes (1885) observed a similar condition in *Campanula americana.* The tapetum in *Specularia perfoliata* persists throughout the life of the embryo sac, and is still prominent in the mature ovule. (Figs. 32 and 35.).

The sequence of events in megasporogenesis and embryo sac development are essentially the same for both the open and cleistogamous flowers. The embryo sac is of the "normal" type as described by Schnarf (1931, 1936), and by Maheshwari (1937). The same condition has been reported in *Campanula rhomboidalis* by Guignard (1882), and *Campanula americana* by Barnes (1885).

MICROSPOROGENESIS

Microspore formation appears to follow the usual course of development leading up to the microspore mother cells, and thence to the usual tetrad of microspores. (Figs. 18, 19, 20.). The various stages in microspore formation precede step by step those of megaspore formation. The archesporial cells in the anther are observed about the time that the nucellus appears as a mere protuberance upon the placenta. The microspore mother cells are in reduction division by the time of the appearance of the archesporial cells in the ovules. The microspores are in tetrad formation by the time of the appearance of the megaspore mother cells. The young microspores have become separated by the time of megaspore formation, and they are in one and two-nucleate stages during early phases of the embryo sac.

THE MALE GAMETOPHYTE

The mature pollen grains have from 3 to 4 thin spots in the exine (Fig. 21.). Barnes (1885) observed from 3 to 12 such thin spots in the exine of the pollen grains in *Campanula americana*. The pollen grains become binucleate, and in some cases trinucleate, before leaving the pollen sacs. (Fig. 23.).

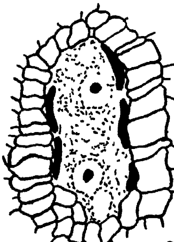
POLLINATION IN THE OPEN FLOWER

Before the flowers open, the anthers lie alongside and overtop the stigma. (Fig. 16.). As the corolla opens, the style elongates and becomes two or more times its original length. (Fig. 15.). As the style elongates, the pollen is dragged out of the pollen sacs by the rigid glandular hairs on the stigma. After the style has completed its elongation, the three lobes of the stigma become conspicuous, and the pollen is observed clinging to the stigma and along the upper part of the style in great abundance (Fig. 17.).

The pollen grains germinate upon the stigma, or at times on the style below the stigma, and the tubes grow downward through the tissue of the style, (Fig. 24.), and not through the stylar cavity. The tubes enter the embryo sac from the stylar tissue and follow the margins of the placentae and funiculi to the micropyles of the ovules. The generative nucleus divides within the pollen grains. They have not been observed dividing in the tubes as reported by Barnes in *Campanula americana*, and by Safijovska (1935) in *Jasione montana, Campanula persicifolia, C. rotundifolia, C. patula* and *C. cervicaria*. The latter observations were made from artificially germinated pollen grains. The sperm nuclei when first formed are spherical, but appear oblong when observed in the tubes. The plugs reported by Barnes in *Campanula americana,* are conspicuous at the ends of the pollen tubes in this species. (Fig. 24.). Upon germination, the pollen tubes protrude by way of a thin spot in the exine of the pollen grain. (Fig. 22.). Of the thousands of pollen grains observed, only a very few were observed germinating.

PLATE II, FIGURES 8-14

8. Two-nucleated embryo sac. Remnants of nucellar cells shown as deeply stained undifferentiated material along the wall of the embryo sac. (From open flower.)
9. Four-nucleated embryo sac. (From open flower.)
10. Eight-nucleated embryo sac. (From cleistogamous flower.)
11. Polar nuclei about to fuse. Egg apparatus and antipodals prominent. (From cleistogamous flower.) Drawn with 10X ocular and 95X objective.
12. Slightly older than figure 11. Early stage in formation of chalazal haustorium. (From cleistogamous flower.)
13. Embryo sac ready for fertilization. Chalazal haustorium prominent. (From open flower.)
14. Fertilization in the open flower.



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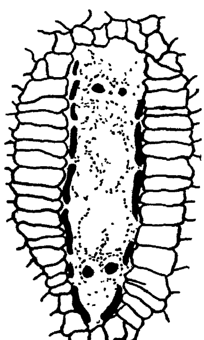

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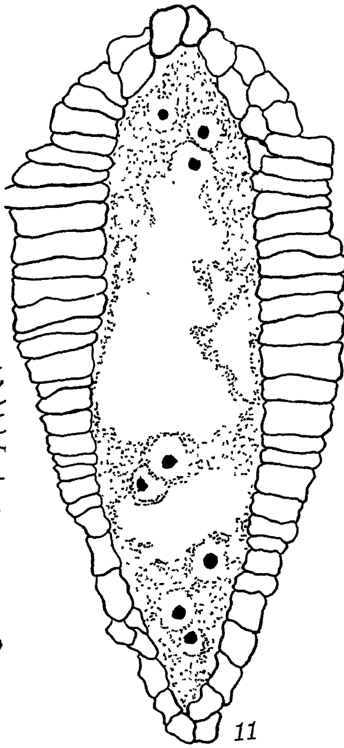

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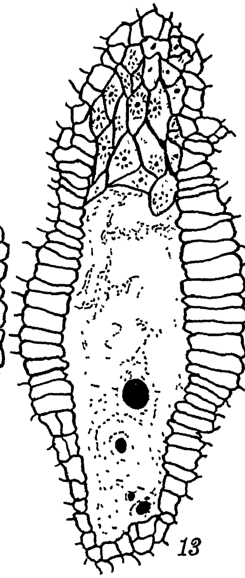

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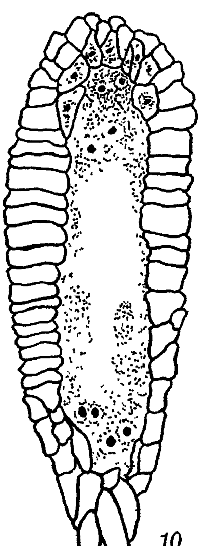

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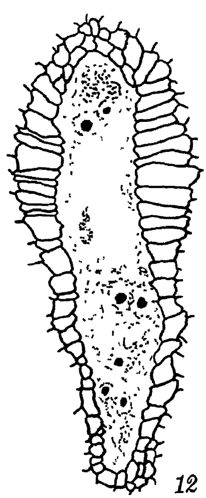

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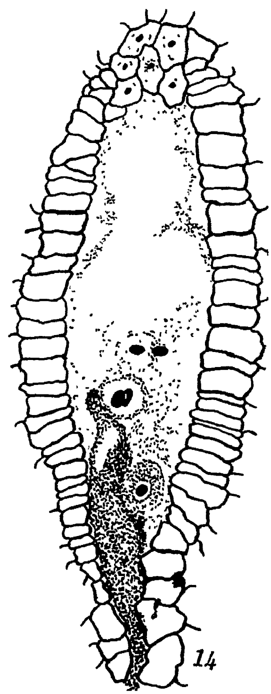

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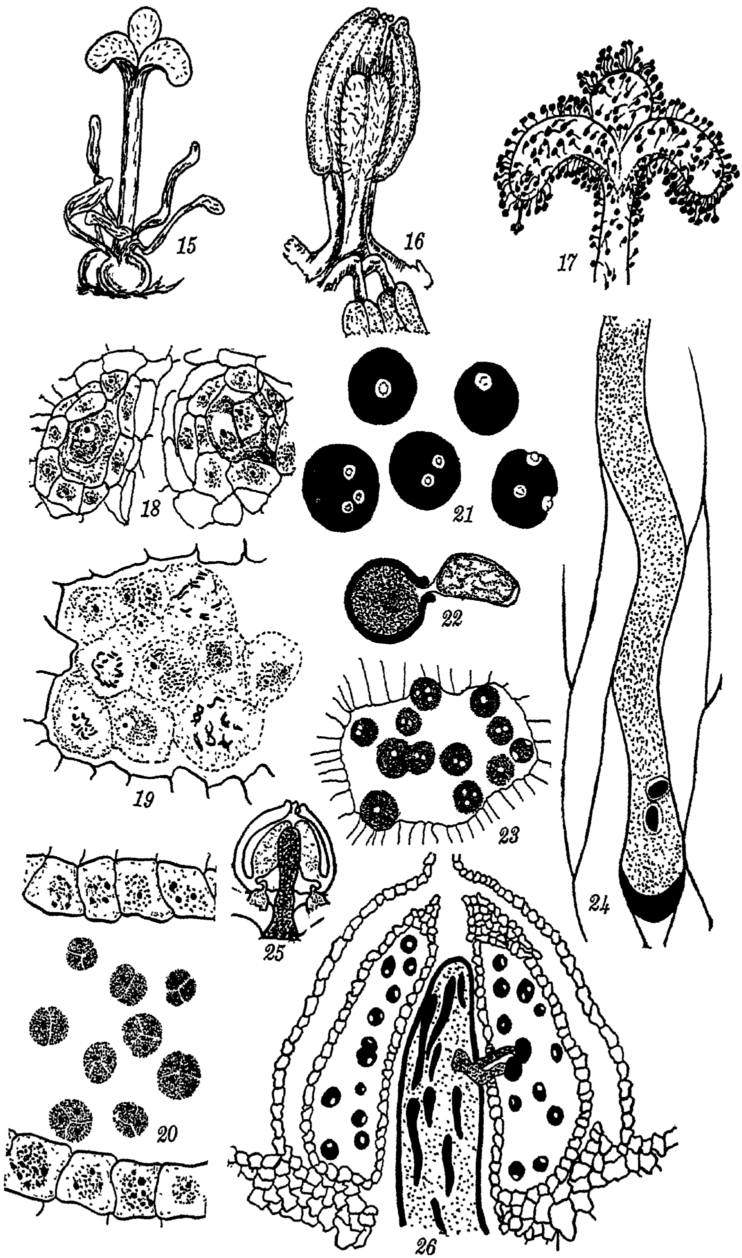
PLATE III, FIGURES 15-26

Fig.
15. Elongated style in open flower following pollination.
16. Stigma in relation to anthers before pollination in the open flower. Note hairs on stigma.
17. Freehand sketch illustrating position of pollen grains upon the stigma and style in the open flower following pollination.
18. Microspore mother cells as seen in cross section at tip of adjacent anthers.
19. Microspore mother cells in reduction division.
20. Young microspores in diad and tetrad stages. Tapetal cells become multinucleate.
21. Mature pollen grains showing characteristic thin spots in exine.
22. Tube emerges from thin spot in exine upon germination.
23. Bi- and tri-nucleated pollen grains in pollen sac of open flower.
24. Pollen tube in stylar tissue showing sperm cells and deeply stained tip.
25. Generalized view of cleistogamous flower showing relative position of stigma and anthers beneath the vestigial unopened corolla.
26. Pollen grains germinating within the pollen sac in cleistogamous flower. Pieces of tubes seen in tissue of stigma and style. Drawn with 6X ocular and 10X objective.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POLLINATION IN THE CLEISTOGAMOUS FLOWERS

The pollen grains do not leave the pollen sacs in the closed flowers as in the open ones, but germinate within the pollen sacs instead. (Fig. 26.). The tubes of the germinating pollen grains penetrate the wall of the pollen sac, where they come in contact with the stigma which is adjacent to the anthers. (Figs. 25, 26.). The "Offungsstelle" of Goebel (1904), or the thin area in the wall through which the tubes pass as described by Ritzerow (1908), have not been observed during the course of this investigation. The tubes pass through the style and into the embryo sac as in the open flower.

FERTILIZATION IN THE OPEN FLOWER

The pollen tube enters the micropyle of the ovule, the sperms are discharged, and fertilization takes place in the usual manner. (Fig. 14.). The actual process of fertilization has been observed in a very few instances, however, the presence of pollen tubes in the style and ovulary, together with numerous embryos, have been commonly observed. About the time that fertilization occurs, the synergids begin to enlarge and migrate far into the micropylar end of the embryo sac, and finally into the micropyle itself. The synergids give rise to a bulbous haustorium. (Fig. 27.). This seems to occur whether fertilization of the egg has taken place or not, for the haustorium is observed in mature seeds which are full of endosperm tissue, but without an embryo. (Fig. 35.). Guignard (1882) observed that the synergids in *Campanula rhomboidalis* develop a beak-like extension. In this species, the haustorium is very conspicuous, appearing more like a bulbous extension into the micropyle.

FERTILIZATION IN CLEISTOGAMOUS FLOWERS

Ritzerow (1908) reported that fertilization took place in the cleistogamous flowers of this species in the usual manner. Fertilization has not been observed actually taking place in the cleistogamous flowers during the course of this investigation, however, there is evidence that such does occur. Pollen grains have been observed germinating within the pollen sacs and their tubes have been traced to the ovulary. No pollen tubes have been observed within the ovules, however. The course of events up to the time of fertilization are identical with those in the open flower, and many embryos have been observed.

The development of some of the ovules in this species appear to resemble that of the parthenogenetic *Thalictrum purpurascens* as described by Overton (1902), in that the egg is delayed in segmenting following fertilization. In this species the division of the fertilized egg is much later that endosperm formation. The embryo sac is usually about filled with endosperm tissue before the egg divides. (Fig. 27.). At any rate, the stimulus for endosperm formation does not depend upon triple fusion. Coulter and Chamberlain (1903, *213*), suggest that in instances where there is a long delay before the egg segments, occasional parthogenesis may be suspected.

EMBRYOGENY

The fertilized egg cell first grows out into a tube-like projection, and near its swollen end the first transverse division takes place producing a rounded apical cell and an elongated basal one. (Fig. 27.). Subsequent divisions of the basal cell results in the formation of a suspensor of five or six cells in

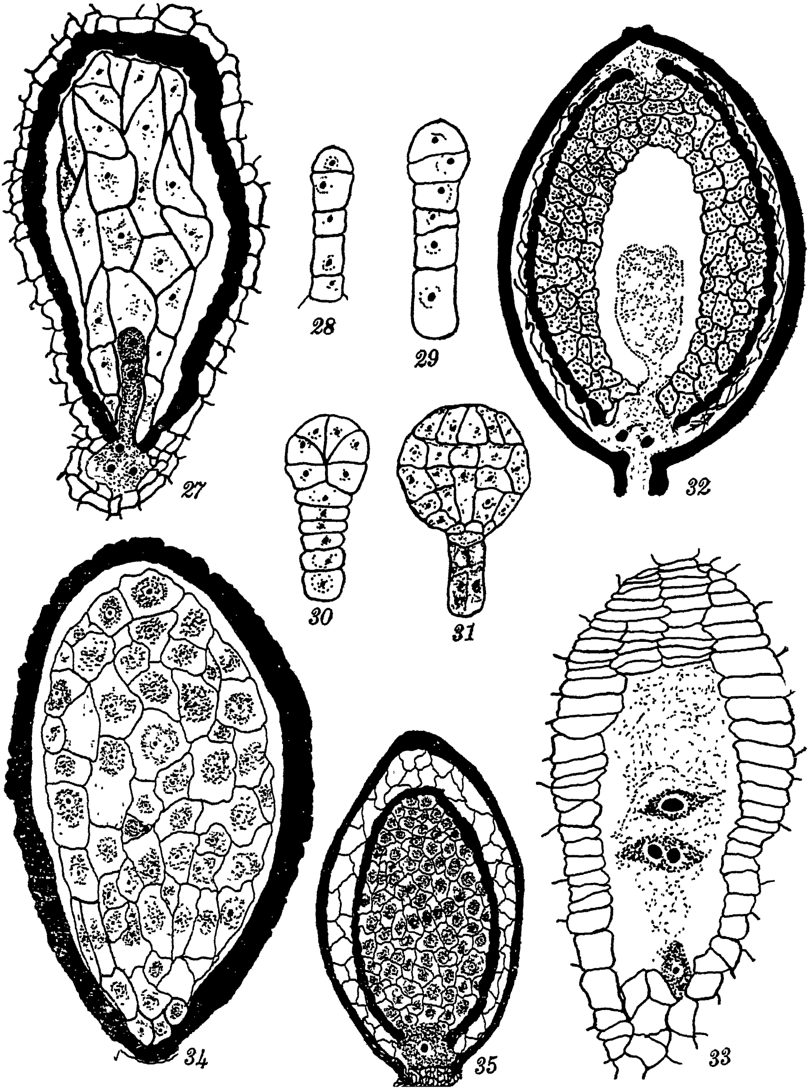

PLATE IV, FIGURES 27-35

27. Embryo sac at the time of first division of the fertilized egg. Walled endosperm cells already fill most of embryo sac. Bulbous micropylar haustorium prominent.

28-31. Various stages in embryo formation (From open flower)

32. Mature embryo. Endosperm heavily laden with starch. Chalazal and micropylar haustoria are still present (From open flower.)

33. Polar nuclei dividing before fusion. (From cleistogamous flower.)

34. Young endosperm completely filling the embryo sac. No embryo is present. (From cleistogamous flower.)

35. Older than Fig. 34. No embryo present. (From open flower.)

length. The apical cell of the proembryo gives rise to the embryo proper, and the suspensor remains short. In general, the development of the embryo in this species appears to follow that of the "Capsella type", typical of dicotyledonous angiosperms. (Figs. 27, 28, 29, 30, 31, 32.). Embryo development in both the open and cleistogamous flowers appears to be identical.

ENDOSPERM DEVELOPMENT

By the time the first division of the fertilized egg cell is complete, endosperm tissue occupies most of the embryo sac, (Fig. 27.). Endosperm formation is of the "walled type". The cells line up in rather definite rows with distinct walls. (Figs. 27 and 34.). A similar condition was observed in *Specularia speculum* by Hegelmier (1886). Whereas endosperm formation may follow triple fusion in this species, it also occurs in the absence of triple fusion, or even in the absence of fusion of the polar nuclei. (Fig. 33.). Furthermore, the endosperm often becomes fully developed in both the open and cleistogamous flowers, without previous fertilization of the egg. (Figs. 34, 35.). Juel (1898) reported in *Antennaria alpina,* a parthenogenetic species, that the polar nuclei do not fuse, but each divides independently and contributes to endosperm. Caldwell (1899) reported in *Lemna minor* that the polar nuclei do not fuse. However, the micropylar polar nucleus produces endosperm tissue, and probably the antipodals ones also. Treub (1898) observed in *Balanophora elongata* and Lotsy (1899) in *B. globosa,* that the polar nuclei do not fuse, but divide independently filling the embryo sac with endosperm tissue. Chodat and Bernard (1900) reported in *Helosis guayanensis* the formation of endosperm entirely from the micropylar polar nucleus, as there is no chalazal polar nucleus formed in this species. Hall (1902) reported the same condition in *Limnocharis emarginata.*

SEED GERMINATION

The seeds of *Specularia perfoliata* require a "rest" period before germination, but this can be shortened by exposure to low temperature. Germination tests showed that 47.5% of the seeds from the open flowers were viable, while only .07% of the seeds of the cleistogamous flowers germinated. Numerous ungerminated seeds of both the open and cleistogamous flowers were soaked in water, dehydrated, embedded, sectioned and stained. These preparations revealed that embryos were not present, with a very few exceptions, although the seeds appeared to be normal and were full of endosperm tissue. (Fig. 35.).

SUMMARY

Investigations concerning the nature of megasporogenesis, microsporogenesis, development of the embryo sac, fertilization and embryogeny have been made, and in general, the conditions were found to be similar in both the open and cleistogamous flowers. In the ovule, the archesporial cell becomes directly the megaspore mother cell. The usual tetrad of megaspores is produced. The chalazal megaspore becomes the functional one, and through its subsequent divisions, forms the "normal" type of embryo sac. The nucellus is only one layer of cells in thickness and is crushed by the encroachment of the enlarging megaspore. Only one integument is formed. A prominent tapetum is present. Antipodal nuclei give rise to a chalazal haustorium. The

synergids give rise to a micropylar haustorium. Triple fusion may or may not occur.

Microsporogenesis follows the usual procedure for most angiosperms. The mature pollen grains are from 2 to 3-nucleated by the time they leave pollen sac. They have from 3 to 4 thin spots in the exine through which the pollen tubes emerge. In the open flowers, the pollen grains are dragged out of the pollen sacs by the rigid glandular hairs on the stigma of the elongating style. Germination takes place on the stigma, and the tubes pass to the ovulary through the stylar tissue. The generative nucleus divides within the pollen grain before germination. The pollen grains germinate within the pollen sacs of the cleistogamous flowers, and after penetrating the wall come in contact with the stigma, after which they follow the same course as in the open flower.

Fertilization has been observed taking place in a few instances in the open flowers, but has not been observed in the cleistogamous flowers. It is believed that fertilization does take place, however, in the cleistogamous as well as in the open flowers. The stages leading up to fertilization are identical in both kinds of flowers, and many embryos have been observed. It is suggested that parthenogenesis might be occasional in this species, due to some similarities with already described parthenogenetic species.

The formation of the embryo is of the "Capsella" type. Endosperm formation is of the "wall" type, and may follow triple fusion, or result from the division of the polar nuclei without fusion. Normally, endosperm tissue fills the embryo sac by the time of the first division of the fertilized egg. In numerous instances the endosperm becomes fully developed in the absence of fertilization of the egg as evidenced by the absence of embryos within the seeds.

LITERATURE CITED

BALICKA-IWANOWSKA, G. P. Contribution à l'étude du sac embryonnaire chez certaines gamepetales. Flora 86:47-71. 1899.

BARNES, C. R. The Process of Fertilization in *Campanula americana*. Bot. Gaz. 10:349-354. 1885.

BARRET, W. C. JR. Heidenhain's Haematoxylin used with the Smear Technic. Stain Techn. 7:63-64. 1932.

CALDWELL, O. W. On the Life History of *Lemna minor*. Bot. Gaz. 27:37-66. 1899.

CHODAT, R., and C. BERNARD. Sur le sac embryonnaire de l' *Helosis guayanensis*. Jour. Botanique 14:72-79. 1900.

COULTER, J. M. and C. J. CHAMBERLAIN. *Morphology of Angiosperms*. Appleton. New York. 1903.

GOEBEL, K. Die kleistogamen Blüten und die Anpassungstheorien. Biol. Zentrabl. 24:673-697. 1904.

GUIGNARD, L. Rescherches sur le embryonnaire des phanerogames angiospermes. Ann. Sci. Nat. Bot. 13:136-199. 1882.

HALL, J. G. An Embryological Studv of *Limnocharis emarginata*. Bot Gaz. 33:214-219. 1902.

JUEL, H. O. Parthenogenesis bei *Antennaria alpina* (L.) R. Br. Bot. Centbl. 74:369-372. 1898.

LOTSY, J. P. *Balanophora globosa* Jungh. Eine wenigstens örtlich-verwittwete Planze. Ann. Jard. Bot. Buitenzorg II 1:174-186. 1899. (Cited from Coulter and Chamberlain.).

MAHESHWARI, P. A. Critical Review of the Types of Embryo Sacs in Angiosperms. New Phytol. 36:359-417. 1937.

Overton, J. B. Parthenogenesis in *Thalictrum purpurascens*. Bot. Gaz. 33: 363-375. 1902.
Ritzerow, Helene. Über Bau und Befruchtung kleistogamen Blüten. Flora 98:163-212. 1908.
Safijovska, L. D. Spermatogenesis bei Campanulaceen. Bull. Sci. Etat. Kiev. 265-278. 1935.
Schnarf, Karl. Vergleichende Embryologie der Angiospermen. Berlin. 1931.
———. Contemporary Understanding of Embryo Sac Development Among Angiosperms. Bot. Rev. 2:565-585. 1936.
Trent, J. A. Floral Variations in *Specularia perfoliata* (L.) A.DC. Am. Midl. Nat. 23:448-454. 1940.
Treub, M. L'organe femelle et l'apogamie du *Balanophora elongata*. Ann. Jard. Bot. Buitenzorg 15:1-22. 1898. (Cited from Coulter and Chamberlain.)

18

The Determination of Iodides in Stabilized Iodized Salt
I. Reducing Type Stabilizers

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Recently the level of iodides in iodized salt has been lowered to one part of potassium iodide per ten thousand parts of salt. This reduction was brought about through the collaborative efforts and recommendations made by: American Public Health Association, Committee on Study of Endemic Goitre; National Research Council, Committee on Food and Nutrition; American Medical Association, Council on Food and Nutrition.

As a result of the above work, the American Public Health Association Committee presented the following resolution in January, 1942: (13)

> "RESOLVED, That all salt for table use of human beings and salt used for feeding to domestic animals in the United States should contain one hundredth of one per cent of Potassium Iodide or its equivalent, *viz.*, forty-five milligrams of Potassium Iodide to each pound of salt, provided that an effective stabilizer be used."

A definition of an effective stabilizer for the potassium iodide content of iodized salt has been formulated through the work at the University of Wisconsin resulting in the issuance of a patent to the Wisconsin Alumni Research Foundation. (11).

Because of these facts, it is likely that we shall see more and more emphasis upon the widespread use of iodized salt to replace ordinary table salt. A dependable method for its analysis is therefore desirable.

Several methods have been available for the estimation of iodides in iodized salt (2, 3, 9, 4, 12) but one of the most satisfactory was the volumetric method proposed by Sadusk & Ball (1). It is the purpose of this work to examine the possibilities of the Sadusk-Ball procedure at the new lower levels, particularly in the presence of reducing stabilizers such as sodium thiosulfate and dextrose.

REAGENTS AND APPARATUS

STANDARD POTASSIUM IODATE SOLUTION. This solution was made up from reagent iodate which had been recrystallized and dried to constancy at 180°C. Tests for iodides using the Rosin method were negative (10).

STANDARD THIOSULFATE SOLUTIONS. Five gallon batches of sodium thiosulfate solutions of 0.02 N. were made up from reagent grade and stabilized according to the method of Kassner and Kassner (6) by the addition of sodium carbonate and chloroform. For titrations, portions of this standardized solution were diluted to normalities ranging from 0.004-0.008 N. No difficulty was experienced with change in the stronger stock solutions. Small portions of the more dilute thiosulfate were made up daily.

STANDARD POTASSIUM IODIDE SOLUTION.—The iodine content of a reagent stock of potassium iodide was determined, employing the precautions suggested by Hillebrand & Lundell (5). It was a simple matter to obtain any

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desired level of potassium iodide for salt mixtures by making up dilute solutions of this standardized potassium iodide and taking appropriate portions.

STARCH INDICATOR.—This reagent was made up from soluble starch using minute quantities of mercuric iodide as preservative, suggested by Kolthoff & Sandell (7). Portions of this reagent kept through several months under ordinary laboratory conditions gave no difficulty.

BROMINE.—Several milliliters of reagent liquid bromine are introduced into a 500 ml glass-stoppered bottle about two-thirds filled with distilled water. To use, gently shake the bottle, remove stopper, tilt bottle mouth carefully over each flask allowing the vapor to flow by gravity into the sample flask. Avoid adding any of the bromine water or liquid. Bromine vapor alone is most satisfactory.

OTHER REAGENTS AND APPARATUS.—Double-distilled water was used for all determinations and blanks were run on the various reagents to determine the absence of iodine. Glass beads were used to prevent bumping in the boiling of the oxidized iodine solutions. Ordinary reagent potassium iodide crystals were used to liberate the iodine from the oxidized mixtures: these crystals were checked for the absence of iodate by the method of Rosin (10). All other necessary volumetric apparatus was calibrated. A calibrated 10 ml buret graduated in 1/20 ml divisions was used for the titrations. Weights calibrated against Bureau of Standards standard masses were used.

ANALYTICAL PROCEDURE USED

The Sadusk-Ball procedure involves the classic iodometric titration of iodate formed from the original iodide by oxidation with bromine. This iodate is reduced by the addition of potassium iodide crystals to free iodine. In this way six atoms of iodine are titrated for each atom originally present in the iodized salt sample.

$$2\,I^- + 5\,Br_2 + 6\,H_2O = 2\,IO_3^- + 10\,Br^- + 12\,H^+ \qquad (A)$$

$$IO_3^- + 5\,I^- + 6\,H^+ = 3\,I_2 + 3\,H_2O \qquad (B)$$

$$2\,S_2O_3^{=} + I_2 = S_4O_6^{=} + 2\,I^- \qquad (C)$$

The slightly-modified procedure used is:

> A 50-gram portion of the salt is placed directly in a liter volumetric flask together with approximately 700 ml water. The alkalinity is carefully neutralized with 2N H_2SO_4 to a persistent red with methyl orange indicator. A 20 ml excess acid is added and the solution diluted to one liter quantitatively. 100 ml aliquots are pipetted into 250 ml erlenmeyer flasks and bromine vapor introduced by inclining the mouth of a bromine-water bottle over each flask thus allowing the vapor to enter by gravity. Swirl the flasks and continue the addition of bromine vapor until the solutions are distinctly yellow. Avoid the addition of bromine water. Drop in 4 or 5 glass beads and boil till colorless, then three minutes more. Wash down the sides of the flask with water until enough is added to replace that lost during boiling. Cool to below 25°C by placing in a shallow trough through which cold water is running. Now add a few crystals of potassium iodide (iodate-free), swirl the flask gently and titrate immediately with 0.004-0.008 N thiosulfate using a 10 ml buret or microburet. Continue until the iodine color fades, then add 5 ml starch solution and titrate to the colorless endpoint.

RECOVERY OF IODIDES IN PRESENCE OF THIOSULFATE

Sadusk and Ball called particular attention to the influence of bromides in the determination of iodides. Their work indicates that bromide concentra-

tions over that which gives a bromide to iodide (Br^-/I^-) ratio of 30 to 1 cause losses of appreciable iodine in the determination.

Modern stabilized iodized salts using the Wisconsin University stabilizers contain either sodium thiosulfate or dextrose for the stabilization of iodine. Thus for example, the ingredient listing on a commercial iodized table salt reads:

> "1/100 of 1% potassium iodide, 1/10 of 1% sodium thiosulfate, 1/10 of 1% calcium oxide and 1% magnesium—calcium basic carbonate added."

Consequently when such a salt is dissolved in acid solution and bromine vapor added the thiosulfate may be oxidized as follows (8):

$$S_2O_3^{=} + 5\,Br_2 + 5\,H_2O = 2\,SO_4^{=} + 10\,H^+ + 10\,Br^- \qquad (D)$$

A simple computation of the amount of bromides introduced in such a reaction by the above salt indicates a ratio of 66 parts of bromide for each part of iodide coming from the thiosulfate. Lower levels of iodides would cause correspondingly higher bromide to iodide ratios if the percentage of thiosulfate in the salt remained constant. In either case however the ratio is within the range suggested by Sadusk and Ball as one in which a substantial part of iodides will be lost in the procedure.

A series of tests was devised to check on the recovery of potassium iodide from iodized salt mixtures at various levels of thiosulfate percentage. The mixtures were made up very simply by placing 50 grams of iodine-free table salt in a liter volumetric flask in which there was a definite quantity of sodium thiosulfate standard solution (measured by calibrated buret). To this solution was added approximately 700 ml of water, a definite measure of standard potassium iodide solution, a 20 ml excess of 2N sulfuric acid and 100 ml aliquots taken after diluting to 1000 ml volume. The samples were then treated as under the standard analytical procedure given above.

TABLE I. Recovery KI in presence of added $Na_2S_2O_3$*

Actual KI in mgms.	Per cent $Na_2S_2O_3$							
	0.00	0 04	0.08	0.12	0.16	0.20	0.24	0.28
0.277	.277	.278	.278	.277	.277	.271	erratic	erratic
0.506	.506	.508	.507	.508	506	.500	.495	erratic
1.008	1.007	1.006	1.004	1.003	1.002	.977	erratic	erratic

*Average of six determinations.

Table I indicates the excellent recoveries obtained in the usual range with which commercial iodized salt is stabilized with thiosulfate, *viz.,* 0.1% sodium thiosulfate. At a concentration of 0.2% sodium thiosulfate the method begins to deviate markedly and above this level of thiosulfate it is difficult to obtain consistent results.

RECOVERY OF IODIDES IN THE PRESENCE OF DEXTROSE

At present the other commonly-used commercial stabilizer for iodized salts is dextrose. A similar set of experiments was therefore devised to check on the recovery of potassium iodide from salt mixtures containing known quantities of pure dextrose. The samples were made up exactly as those described under the thiosulfate tests except for the substitution of dextrose. The tests were confined to three levels of dextrose, namely, 0.1%, 0.2% and 0.3%. An examination of the reaction involving the oxidation of dextrose by bromine

vapor to d-gluconic acid reveals a much lower quantity of bromide ions introduced per unit of stabilizer:

$$H_2O + C_6H_{12}O_6 + Br_2 = HOCH_2(CHOH)_4COOH + 2\,Br^- + 2\,H^+ \quad (E)$$

For this reason less difficulty was anticipated. Thus for example a salt containing 0.1% dextrose as stabilizer and 0.01% potassium iodide will give when treated with bromine vapor a bromide concentration (see Equation (E) such that the bromide/iodide ratio is approximately 11:1.

TABLE II. Recovery KI in presence of added dextrose*

Actual KI in mgms	Per cent dextrose 0.00%	0.10%	0.20%	0.30%
0.277	.278	.277	.277	.277
0.506	.506	.505	.506	.506
1.008	1.007	1.008	1.009	1.006

*Average of six determinations each.

Recoveries are remarkably consistent in the presence of the percentages of dextrose in iodized salt indicated.

RECOVERY OF POTASSIUM IODIDE FROM IODIZED SALTS USING COMMERCIAL STABILIZERS

A series of known iodized salt mixtures was made up in volumetric flasks using commercial stabilizers and checked for iodine content. Recovery from non-stabilized salts is included for reference. The procedure was the same as that followed in the thiosulfate experiments described previously in this paper, excepting that weighed quantities of commercial stabilizers were introduced with each 50 gram portion of iodine-free salt.

TABLE III. Recovery of iodides from iodized salts

No. Tests	Added	Recovery	Precision	Error	Stabilization Added
7	0.01293%	0.01285%	±0.00001%	—0.00008%	None
10	.00549	.00549	± .00000%	0.00000	None
6	.00549	.00542	± .00000%	—0.00007%	0.2% "H" Added
7	.00549	.00542	± .00000%	—0.00007%	0.1% Dextrose
8	.00549	.00532	± .00006%	—0.00016%	0.5% Dextrose
8	.00549	erratic	......	......	1.0% "H" Added
7	.00554	.00541	± .00004	—0.00012%	0.5% Dextrose
16	.00554	erratic	......	......	0.4% "H" Added
7	.00554	.00554	± .00004%	0.00000	None
4	.01034	.01032	± .00000%	—0.00002%	None
8	.01036	.01035	± .00001%	—0.00001%	None
7	.01036	.01031	± .00000%	—0.00005%	0.2% "H" Added
5	.01036	.01031	± .00000%	—0.00005%	0.1% Dextrose
4	.01312	.01311	± .00001%	—0.00001%	0.2% "H" Added
8	.01386	erratic	......	......	0.4% "H" Added

"H" = Commercial stabilizer = ½ $Na_2S_2O_3$ + ½ CaO

The column marked "Precision" indicates the degree of reproducibility, i.e., maximum variation from average obtained in the tests, while the column marked "Error" indicates the actual deviation from the added quantity. The results in Table III further indicate that determinations of iodides by this method in the presence of 0.2% sodium thiosulfate and more are not consistent. Note also the low result obtained in the case in which 0.5% dextrose stabilizer was added.

Commercial stabilizers of the thiosulfate type usually come admixed with about half their weight of an alkaline material such as calcium oxide or sodium carbonate.

APPLICATION OF THE METHOD TO IODIZED SALTS IN STORAGE TESTS

A number of salt samples were stored protected from direct sunlight and dust in open glassine-lined opaque paper bags. Tests for iodine were made at the beginning and end of the storage periods as indicated in Table IV.

TABLE IV. Loss of iodine in storage of iodized salts

Type	Initial	Days Storage	Final	Stabilized	Remarks
Table Salt	0.0271%	319	0.0244%	0.1% Dextrose	10% Loss
Table Salt	0.0241%	319	0.0238%	0.2% "H"	"H"=½ $Na_2S_2O_3$+½ CaO
Table Salt	0.0186%	60	0.0145%	No	22% Loss
do	0.0186%	180	0.0132%	No	29% Loss
do	0.0186%	320	0.0094%	No	50% Loss
Mineral Supplement Salt	0.0252%	540	0.0253%	0.2% "I"	"I"=½ $Na_2S_2O_3$+ ½ Na_2CO_3

Other samples placed in glass containers such as open salt shakers unstabilized have shown losses as high as 50% of the iodine content in three weeks time whereas stabilized salts under the same conditions have shown less than 5% losses.

CONCLUSIONS AND SUMMARY

1. The Sadusk-Ball procedure for the volumetric determination of iodine in stabilized iodized salt is satisfactory when the thiosulfate content of the salt mixture does not exceed 0.16%.
2. The method is satisfactory in the presence of 0.3% dextrose (in dextrose-stabilized iodized salt).
3. The Sadusk-Ball procedure is satisfactory for levels of iodide as low as 0.005% potassium iodide in the presence of the quantities of stabilizers mentioned above.

BIBLIOGRAPHY

1. BALL and SADUSK, Ind. Eng. Chem. Anal Ed. 5, No. 6, 386-9 (1933).
2. DUNN, Analyst, 53, 211 (1928).
3. FELLENBERG, VON, Biochem. Z. 139, 371 (1923); 176, 364 (1926).
4. GEAGLEY, Am. J. Pub. Health 19, 923 (1929) or see SNELL, "Colorimetric Methods of Analysis" Vol. I, p. 569, D. Van Nostrand Co., 1936.
5. HILLEBRAND & LUNDELL, "Applied Inorganic Analysis" p. 591, Wiley, 1929.
6. KASSNER & KASSNER, Ind. Eng. Chem. Anal. Ed. 12, No. 11, 655 (1940).
7. KOLTHOFF & SANDELL, "Textbook of Quant. Inorganic Anal." p. 589, Macmillan, 1936.
8. MCALPINE & SOULE, "Prescott & Johnson's Qualitative Chemical Analysis" p. 509, D. Van Nostrand Co., 1933.
9. NICHOLS, Am. J. Pub. Health 19, 923, (1929).
10. ROSIN, "Reagent Chemicals and Standards," D. Van Nostrand Co., 1937.
11. U. S. Patent No. 2,144,150, Jan. 17, 1939.
12. WINKLER, Z angew Chem 28, 494, (1915).
13. Private communication to Salt Producers Association, January 19, 1942.

Animal Life in Synthetic Mixtures of Nitrogen, Oxygen, and Water Vapor

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In previous papers (1, 2, 3, 4) it was shown that the life of small animals (white mice) was shortened in a synthetic mixture of 21 per cent oxygen and 79 per cent nitrogen. The present study continues the above experiments using synthetic mixtures of oxygen and nitrogen under different conditions of relative humidity.

The oxygen used for our experiments was obtained from the Puritan Compressed Gas Corporation, Kansas City. This was medically pure oxygen, manufactured both by the electrolytic process and by the liquefaction of air. Such oxygen is never less than 99.5 per cent and is generally 99.9 per cent pure. The nitrogen, 99.7 per cent pure, was obtained from the Matheson Company, East Rutherford, New Jersey.

In using high pressure gases, the usual precautions must be carefully and rigidly observed if maximum safety is to be enjoyed. Thus equipment which has been used with any other gas must not be employed with oxygen because of the danger from oil that may get into the regulator channels or valve openings and cause a serious explosion when oxygen comes in contact with it. If it is desired to work with oxygen, as well as with other gases, two complete sets of unit parts and regulators should be procured.

Cylinders should not be dropped or treated roughly. Cylinders should not be permitted to stand in direct rays of the sun, for heat may cause sufficient expansion of the gas to blow the safety valve, resulting in the loss of the gas even if no damage is done.

White mice were placed in a gallon jar, uncooked oatmeal was used for feed and water was given them daily in such a way that it did not get into their feed and nest. The mixture of gas was made by leading the gases from the two containing cylinders into a bottle through water; same size bubbles were produced and counted and the mixed gases were then passed through concentrated c. p. sulfuric acid, calcium chloride, and soda lime towers. Soda lime and calcium chloride, in a suitable container, were also placed in the gallon jar. The mouse was changed once a week into a clean sterilized jar, which required but a few seconds. The humidity was measured by a Hampton Humidiguide both in and outside the jar; sometimes the relative humidity was determined with a wet and dry bulb thermometer. By these methods, the humidity could not be measured with a high degree of accuracy, but it was determined approximately.

A synthetic mixture of 21 percent oxygen and 79 percent nitrogen gave the following results:

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ANIMAL NO. 1

Sept., 1940	Temp. deg F.	Inside Humidity	Outside Humidity	O_2	N_2	Bubbles of gas per min.	Resp. per min.	Remarks
26			24	30	140	170		Male,
27			26	30	150	180	180	Wt.
28			29	40	150	190	120	22.43 grams
29			35	30	120	150	120	
30			40	24	120	144	150	
October								
1			42.5	20	120	140	200	
2			42.5	60	120	130	240	Wt.
3	72	51		30	112	142	200	16.83 grams
4	73	60		39	144	183	200	
5	73	72		34	140	174	160	
6	73	80		50	140	190	170	
7	78	80		30	134	164	172	
8	79	80		26	115	141	200	
9	75	80		32	120	152	200	Length of
10	73	80		35	144	179	200	life, 15 days Wt. 17.54 grams
11							Mouse dead (high humidity)	

ANIMAL NO. 2

Oct., 1940	Temp. deg. F.	Inside Humidity	Outside Humidity	O_2	N_2	Bubbles of gas per min.	Resp. per min.	Remarks
31	35	53	75	36	138	174	too active	Wt. 19.75 grams Male—New Mouse
Nov.								
1	40	42	79	30	132	162	124	
2	39	55	70	28	112	140	160	
3	42	58	70	40	130	120	160	
4	50	54	76	42	160	202	126	
5	65	45	75	38	150	188	160	
6	65	39	78	36	146	182	135	Wt. 16.6 grams
7	64	40	80	36	160	196	140	Length of life
8	35	44	78	36	156	192	160	in medium hu-
9	38	50	80	30	160	190	150	midity 16 days
10	38	42	68	32	140	172	200	
11	45	25	69	32	152	184	180	
12	55	24	74	30	152	182	210	
13	55	20	72	32	148	180	200	
14	20	18	72	32	160	192		Wt. 14 25 grams Too active to count resp.
15	Gases were running satisfactorily.						Mouse dead.	

ANIMAL NO. 3

1940-41 Dec.	Temp. deg. F.	Inside Humidity	Outside Humidity	O_2	N_2	Bubbles of gas per min.	Resp. per min.	Remarks
26	54	36	62	33	144	173	155	
27	58	34	65	30	120	150	179	
No. 4								
28	62	33	67	26	72	98	240	Resp. high
29	64	35	59	26	90	116	228	
30	71	33	70	40	136	176	124	Wt. 16.33 grams
31	49	37	71	40	124	164	122	Mouse lost 1.5 grams
Jan.								
1	48	37	67	36	138	174	126	
2	47	37	62	35	86	121	140	
3	48	26	72	36	68	104	116	
4	46	23	72	34	152	186	196	
5	47	22	73	31	124	155	148	
6	45	23	74	32	116	148	124	
7	46	21	76	32	114	146	104	
8	45	24	78	36	112	148	108	
9	46	24	78	34	112	146	116	
10								Mouse dead
No. 5								
14	40	27	81	32	128	160	too active	Wt. 17.15 grams Mouse dead; oxygen stopped.

ANIMAL NO. 6								
1941 April	Temp. deg. F.	Inside Humidity	Outside Humidity	O_2	N_2	Bubbles of gas per min.	Resp. per min.	Remarks
29								Wt. 16.69 grams
30	33	85	72	60	150	210	140	Female
May								
1	37	75	70	30	140	150	156	
2	38	79	71	30	140	170	182	
3	39	74	71	28	152	180	196	
4	39	62	70	28	130	158	200	
5	41	60	75	28	144	172	192	
6	40	56	72	24	110	134	220	Wt. 12.09 grams
7	34	49	71	34	152	186	210	
8	34	50	75	28	136	164	240	
9	33	56	80	30	120	150	216	
10	34	56	72	32	176	208	224	
11	35	59	72	34	136	170		24 days low humidity 33-46
12	35	73	74	32	132	164	236	
13	46	72	76	32	186	218	210	Wt. 12.13 grams
14	44	61	75	32	148	180	176	
16	44	61	76	32	164	196	136	
17	44	60	75	32	120	152	168	
18	42	52	75	32	120	152	130	
19	44	73	78	32	162	194	180	
20	45	72	76	32	120	152	160	Wt. 10.66 grams
21	45	73	76	32	200	232	120	
22				32	132			Mouse dead

In general, if conclusions may be drawn from the few cases cited above, animals live longer in a synthetic atmosphere of oxygen and nitrogen (in the absence of the rare gases) than with either medium or high humidity. In a few cases, mice lived for several weeks with low humidity. By low humidity is meant any value less than 30 percent and by high humidity is meant any value in excess of 75 percent.

LITERATURE CITED

1. HERSHEY, J. WILLARD. "Animal Life in Synthetic Mixtures of Oxygen and Nitrogen." Trans. Kan. Academy of Science 33:133-35. 1930.
2. HERSHEY, J. WILLARD. Science 71:394. 1930.
3. HERSHEY, J. WILLARD. Anesthesia and Analgesia, 13:238-239.
4. HERSHEY, J. WILLARD, and WAGONER, CHARLES. Trans. Kans. Acad. Science, 42:217-219, 1939.

Addition Agents in the Electro-Deposition of Lead

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The study of the effect of addition agents on the form of electrodeposited lead is not a new one. With a few singular exceptions, however, such studies have included plating baths of the fluorosilicate, fluoroborate, or acetate type; that is, the baths more commonly used in industrial lead plating.

In the exceptions noted above it has been found that a smooth, dense, brittle deposit of lead could be obtained from a bath containing 10 per cent lead nitrate, 2 to 5 per cent acetic acid, and 1 per cent of a residue obtained from the commercial extraction of Curacao aloes in the manufacture of aloes. Various concentrations of salt, acid, and residue and variation of current density were tried. Some forty other addition agents (mostly pharmaceuticals) were used in addition but the above formula was the most effective.[1]

Other investigators report the use of glycocoll, tannin, resorcinol, licorice, and gelatin as addition agents in lead nitrate plating baths.[2,3] The concensus of opinion is that they exert little, if any, effect on the form of the electrodeposit.

EXPERIMENTAL

The purpose of this study was to determine whether or not any relationship exists between the nature of the addition agent and the form and the mass of the electrodeposited lead and is similar to the work done by Taft and Horsley on silver.[4]

Preliminary experiments showed that the fineness of deposits of lead from a lead nitrate bath increased with increasing concentration of lead nitrate and with decreasing current density. As a result of these preliminary trials, electrolysis was carried out at a current density of 2.0 amperes/dm.^{2} at 30°C., using a 1.4 molal solution of lead nitrate as the standard bath. One hundred cc. beakers were used as bath containers and the electrodes were approximately two centimeters apart. The current density was chosen in accordance with that used in commercial baths. Because of the somewhat greater ease of preparation a 1.4 molal rather than a 1.4 molar solution was used.

The current employed was 0.272 amperes for electrodes of 9.0 cm.^{2} area. This value was calculated by assuming the effective area of the electrode to be 1.5 times the area of one face. The time of electrolysis was approximately 20 minutes, giving a deposit of approximately 0 280 grams.

The anodes consisted of strips of sheet lead cleaned in nitric acid, while the cathodes were lead foil cleaned in the same solvent.

Solutions were run in duplicate. The concentration of the addition agent was 0.014 molal for substances whose molecular weight was known and 0.1% by weight for substances of unknown molecular weight. Most of the dyes used were only slightly soluble and of quite high molecular weight and in these instances 0.1% by weight of the dye was used, since it was deemed

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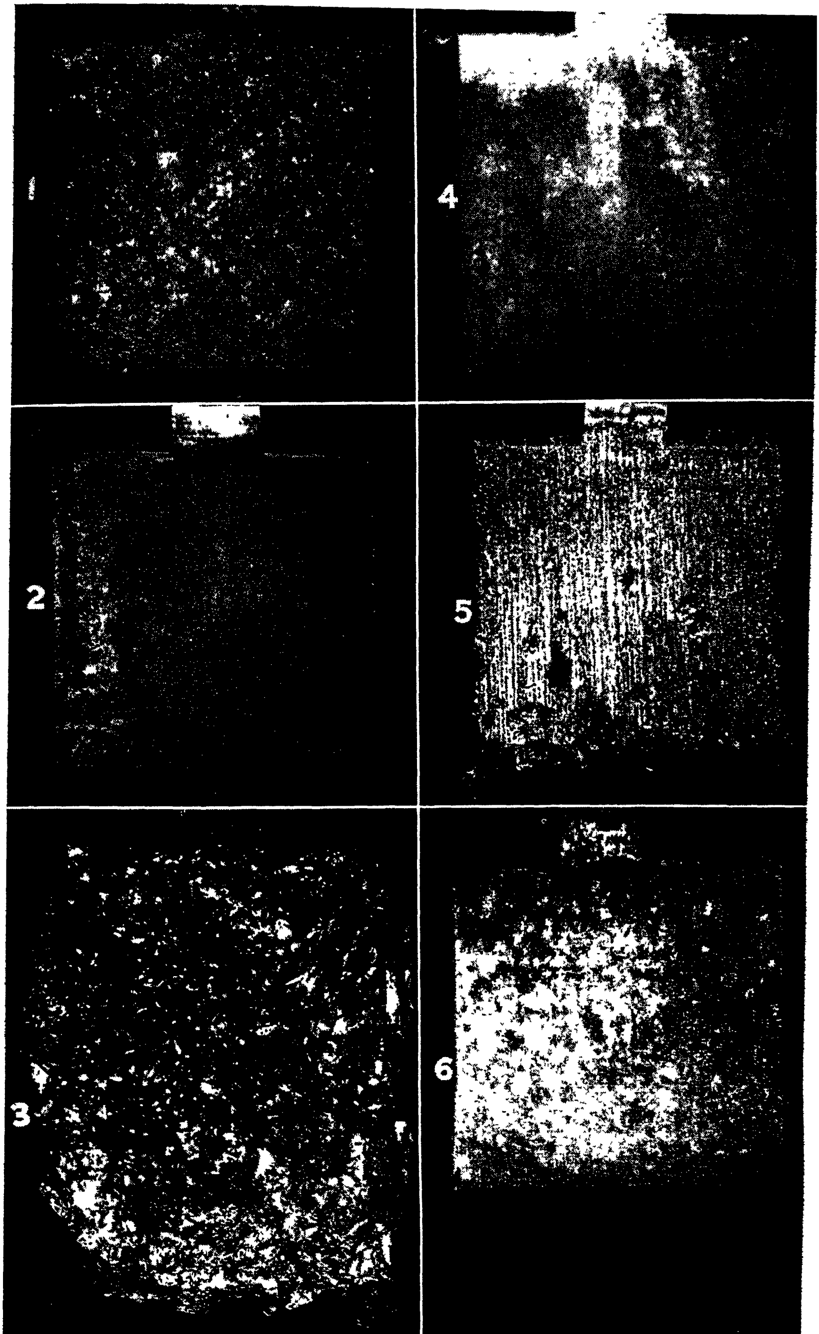
FIGURE 1.

Typical deposits of lead obtained in the presence of addition agents (X1½): No. 1, lead nitrate alone (control); No. 2, silver nucleinate (No. 130); No. 3, tetra-brom cresol-sulfonphthalein (No. 186); No. 4, brom cresol purple (No. 35); No. 5, ortho nitrobenzoic acid (No. 26); No. 6, dianisidine (No. 55).


1
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more in keeping with the amounts of substances with average molecular weight. All solutions not clear were filtered by means of ordinary filter paper.

In weighing the deposits great difficulty was encountered. In the majority of cases some of the deposit was lost before a weighing of the deposit could be made. This condition was particularly true of the control deposits. Toward the end of the electrolysis long, bright, needle-like crystals of lead appeared around the corners of the cathode and invariably part, if not all, of these crystals dropped off when the electrode was removed from the bath. For this reason only an estimate of the weight of the controls was possible. For this same reason the current efficiency of only a few of the experimental baths could be calculated.

The classification of the form of the deposit is based on a macroscopic examination (and microscopic in the case of the first three classes defined below) of the electrode as compared to the macroscopic appearance of the control deposit run under the same conditions. The classes adopted in the data given below are as follows: *Fine* when the deposit, macroscopically and microscopically, appears much smoother than the deposit obtained from the control bath; *Intermediate* when the smoothness of the deposit lies between that of the control and that of the smoothest deposit; *Control* or *Standard* when the appearance of the deposit is almost identical with that of the control; *Coarse* when the crystal size of the deposit is of the same type, but considerably larger, than the control; *Abnormal* when the deposit consisted of large plates or when one axis of the crystal was developed to a much greater extent than the others; *Striated* when the deposit formed distinct striae. The results obtained from 196 different addition agents are tabulated below In nearly all baths, treeing occurred around the edges of the cathode although the smoother deposits usually contained fewer "trees". In addition, considerable variation was found in the color of the deposit. The usual effect —when any difference in color occurred between the control and a given deposit—was to produce a darker colored product.

EXPERIMENTAL RESULTS

1. Acetamide, 0.014M.

The deposit was very similar to the *Control* and was classed as such.

2. 3-nitro 4-methyl omega-chloro-acetanilide, saturated solution. *Control.* The addition agent was only slightly soluble.

3. Acetic acid, 0.014M. *Control.*

4. Aceto-acetic ester, 0.014M. *Control.*

5. *Acetone,* 0.014M. *Control.*

6. Acetyl phenyl hydrazine, 0.014M. *Control.*

7. Adipic acid, 0.014M.

The deposit was considerably finer than the control and slightly more adherent than the control; treeing was still considerable. *Intermediate.*

8. Agar agar, 0.1% saturated solution.

The deposit was more coarse than the control and slightly darker; classed as *Coarse.*

9. Alanine, 0.014 M.

The deposit was similar to that of No. 7, and was classified as *Intermediate.*

10. Aniline, 0.014M.

On the addition of the aniline to the stock solution a precipitate of aniline nitrate appeared. The filtered solution gave a deposit similar to the *Control* and was classified as such.

11. Albumen, blood, saturated solution.

The deposit had the appearance of an *Intermediate* deposit but there was considerably more treeing than on the control.

12. Albumen, egg, saturated solution.

The deposit had the appearance of the *Control* and was classified as such.

13 Alizarol black 3G, saturated solution. *Striated.*

The deposit was the color of the control and showed marked striations; the striations continued beyond the edge of the electrode in the form of trees.

14. Alizarol R B, saturated solution. *Intermediate.*

The crystals of the deposit were finer than those of the control and the amount of treeing was somewhat less.

15. Aniline blue, saturated solution. *Control.*

16. Aniline red, saturated solution.

Aniline red is fairly soluble and gives a red solution. The deposit obtained was fairly light in color and *Intermediate* in texture; slight amount of treeing.

17. Arsanilic acid, saturated solution.

On commencing electrolysis, the solution turned dark and a dark, flocculent deposit appeared on the face of the cathode. This deposit fell off on removal of the cathode from the bath. A fine, dark, powdery deposit of lead remained on the cathode. This deposit was classed as *Abnormal.*

18. Basic fuchsin, saturated solution.

Basic fuchsin is partially soluble in the standard solution. The deposit was slightly *Striated* and small flat plates were superimposed on the striations.

19. Benzidine, saturated solution.

Benzidine is only slightly soluble. The deposit is similar to the *Control* and is classified as such. Slightly finer on face of electrode.

20. Benzene, 0.014M.

The deposit had every appearance of the *Control* and was classified as such.

21. Benzil, saturated solution.

The deposit was of the same type as the *Control* and slightly coarser but was classified as a control.

22. Benzilic acid, saturated solution.

The deposit had every appearance of the *Control* and was classified as such.

23. Benzo-azurine, saturated solution.

The face of the electrode was an *Intermediate* in texture, dull grey in color, and considerably treeing on the edges of the cathode.

24. Nitro-benzoic acid, meta, saturated solution.

The deposit was very slightly *Striated* and black in color. It was very soft and non-adherent.

25. Nitro-benzoic acid, para, saturated solution

The deposit was somewhat more *Coarse* than the control and slightly darker in color.

26. Nitro-benzoic acid, ortho, 0.014M.

The deposit was very markedly *Striated;* the striations continued beyond the edges of the electrode in the form of trees.

27. Benzoin, saturated solution.

Benzoin is slightly soluble. The deposit appeared to be measurably *Coarser* than the control and was so classified.

28. Benzopurpurin, saturated solution.

Benzopurpurin is slightly soluble. The deposit was *Intermediate* in texture, bright, but with more treeing on the edges of the electrode than in the control.

29. Benzoyl peroxide, saturated solution.

Benzoyl peroxide is very slightly soluble. The deposit was slightly more *Coarse* than the control. Microscopically they resembled the standards.

30. Benzthiazole, 1-immino, 5-methyl, saturated solution.

Benzthiazole is slightly soluble. The deposits appeared to be very good *Intermediate* plates but there was considerable treeing around the edges of the electrode.

31. Bismark Brown, saturated solution.

This dye was somewhat soluble. The deposit was almost as fine as that in No. 30, and was classed as *Intermediate;* it was light grey in color.

32. Boric acid, 0.014M.

The deposit in this case was *Coarse* enough to be classed as such; microscopically the crystals appeared to be similar to those of the standard.

33. Brom phenol blue, saturated solution.

The brom phenol blue was partially soluble. The deposit from this bath resembled that from arsanilic acid in almost every detail. This deposit was classed as *Abnormal.*

34. Brom thymol blue, saturated solution.

Brom thymol blue was partially soluble. This deposit resembled the deposit obtained in No. 33, except that it was slightly finer in texture. Classified as an *Abnormal* deposit.

35. Brom cresol purple, saturated solution.

The deposit in this case was one of the best obtained. It was deep grey in color, *Fine,* and had no appreciable treeing on the edges of the electrode.

Mass of the deposit.. 0.2791 gms.
Cathode efficiency 99.2%

36. Benzoyl glycine, 0.014M.

The deposit resembled the *Control* in every respect and was classified as such.

37. Blood serum, saturated solution.

As above, the deposit resembled the *Control* in every respect and was classified as such.

38. Butyric acid, normal, 0.014M.

This addition agent gave a deposit slightly finer than the control which was classified as a *Control.*

39. Caffeine, saturated solution.

This deposit resembled the *Control* in every respect and was classified as such.

40. Caproic acid, 0.014M.

This deposit was somewhat darker than the *Control* but otherwise resembled the standards and was classified as such.

41. Calcium gluconate, saturated solution.

This deposit resembled the control but was slightly darker. It was classified as a *Control.*

42. Brilliant Green.

As above, the deposit resembled the *Control* and was classified as such.

43. Carbon disulfide, saturated solution. *Control.*

Here again the deposit was quite dark in color but resembled the standard in texture.

44. Casein, saturated solution.

In this instance the electrode was a little less treed but in all other respects resembled the *Control.*

45. Chrysoidine Y, saturated solution.

This deposit had the appearance of a very good *Intermediate* plate but the treeing was excessive.

46. Cinnamic acid, 0.014M, saturated solution.

This agent gave a deposit of the same texture as the *Control.*

47. Citric acid, 0.014M.

This agent gave a deposit of *Intermediate* nature but over which had started to grow many small leafy trees of lead. The deposit was somewhat darker than the control.

48. Congo Red, saturated solution.

Congo red was slightly soluble; the deposit formed resembled the *Control* and was classified as such.

49. Coumarin, saturated solution.

Coumarin was slightly soluble and gave a deposit that was classified as a *Control.*

50. Creatine, saturated solution.

Creatine was slightly soluble and gave a deposit that was classified as a *Control.*

51. Cyanamide, 0.014M.

The cyanamide dissolved and gave a deposit that resembled the *Control* both macroscopically and microscopically.

52. Dextrin, 0.014M.

Here again the deposit plated out resembled that of the *Control* and was classed as such.

53. Diacetin, 0.014M.

Deposit was classed as a *Control.*

54. Diacetyl monoxime, saturated solution. *Control.*

55. Dianisidine, saturated solution. *Intermediate.*

Dianisidine was only slightly soluble but gave a very good intermediate plate that was bright in comparison with the controls, having practically no trees.

56. Dicyandiamide, saturated solution.

The deposit produced by this agent was classed as a *Control.*

57. Dimethyl glyoxime, saturated solution.

The deposit obtained from this bath also was classed as a *Control.*

58. Dioxane, 0.014M.

The deposit from this bath was also classed as a *Control,* both from the standpoint of texture and color.

59. Diazo-amino-benzene, saturated solution.

Here again the deposit was classed as a *Control.*

60. Eosin, saturated solution.

Eosin was very slightly soluble but gave to the solution a characteristic fluorescent appearance. The bottom deposit was quite fine, grey in color and slightly striated, while treeing had begun on the *Striated* face of the electrode.

61. Epichlorohydrin, 0.014M. *Control.*

The deposits were similar to the standards.

62. Ethanolamine, 0.014M.

On addition of the above compound to the stock solution a white salt of ethnaolamine nitrate was precipitated. The deposit from the filtered solution resembled that of the *Control.*

63. Ethylene glycol dibutyrate, saturated solution.

The above agent gave a deposit that was classed as a *Control.*

64. Fluorescein, di-brom, saturated solution.

This compound is very slightly soluble. The deposit consisted of light flaky leaves of lead; similar to the eosin deposit except in greater quantity; was classified as *Abnormal.*

65. Formic acid, 0.014M.

Again this deposit resembled the standards and was classified as a *Control.*

66. Gallic acid, saturated solution.

The deposit obtained from this bath was dark in color and *Intermediate* in texture; there was very little treeing on the edges of the electrode.

67. Glutamic acid, 0.014M.

The deposit obtained from this bath was somewhat darker than the *Control* in color but similar to it in texture.

68. Glycerol, 0.014M.

This deposit resembled the *Control.*

69. Glycine, 0.014M.

Here again the deposit resembled the *Control.*

70. Trimethylene glycol, 0.014M.

This deposit also resembled the *Control.*

71. Gold, colloidal.

The deposit resembled the *Control.*

72. Gum Arabic, 0.1%.

The deposit obtained from this bath was a dull gray in color, *Intermediate* in texture, with considerable treeing on the edges of the cathode.

73. Gum Tragacanth, saturated solution.

The deposit was classed as a *Control.*

74. Hexamethylene tetramine, saturated solution.

The above compound was not completely soluble and gave a deposit classed as a *Control.*

75. Hydroquinone, 0.014M.

This agent gave an intermediate deposit whose color was comparable to that of the *Control.*

76. Indigo, saturated solution.

This compound bordered on complete insolubility in the stock solution and gave a deposit classed as a *Control.*

77. Iodosobenzene, saturated solution.

This agent gave a deposit very similar to the *Control.*

78. Iodoxybenzene, saturated solution.

Here again a deposit analagous to the *Control* was obtained.

79. Isovaleric acid, 0.014M.

The deposit obtained from this bath resembled the *Control.*

80. Lactic acid, 0.014M.

The deposit obtained from this bath resembled the *Control.*

81. Litmus, saturated solution.

The deposit obtained from this bath was very slightly *Striated* and quite dark in color.

82. Maleic acid, 0.014M.

The deposit obtained from this bath resembled the *Control* in color and texture.

83. Malic acid, 0.014M.

The deposit obtained from this bath was slightly *Striated,* with the color and texture of the controls.

84. Mandelic acid, saturated solution.

The deposit obtained from this bath resembled the *Control* in color and texture.

85. Mannite.

Here again the deposit resembled the *Control.*

86. Mannose, 0.014M.

Here again the deposit resembled the *Control.*

87. Mercurochrome, saturated solution.

The deposit obtained from this bath was *Intermediate* in texture with an excessive amount of treeing on the edges of the electrode.

88. Methyl Orange, saturated solution.

The deposit obtained from this bath was *Intermediate* in texture, bright in color, and appreciably treed on the edges of the electrode.

89. Methyl Red, saturated solution.

The deposit obtained from this bath was similar to the *Control.*

90. Methyl Violet, saturated solution.

The deposit obtained from this bath resembled the *Control* in nature and color.

91. Methylene Blue, saturated solution.

The deposit obtained from this bath was *Intermediate* in texture, slightly striated, deep grey in color with very little treeing.

92. Neocyanine, saturated solution.

The deposit obtained from this bath was *Intermediate* in texture with an excessive amount of treeing on the edges of the electrode. The face of the electrode proper was colored green and was one of the very few such cases noted.

93. Night Blue, saturated solution.

The deposit obtained from this bath resembled the *Control.*

94. Nitro-aniline, meta, saturated solution.

The deposit obtained from this bath was noticeably *Striated.* The deposit was dark in color and quite soft.

95. Nitrobenzene, saturated solution.

The deposit obtained from this bath was also *Striated* and dark in color. The striations were quite high and widely spaced.

96. Nitro-phenol, ortho, saturated solution.

The deposit from this bath was not striated and resembled the *Control* except for its somewhat darker color.

97. Nitro-phenol, meta, saturated solution.

The deposit from this bath was *Striated* to a marked degree and rather light in color.

98. Nitro-phenol, para, saturated solution.

This deposit is very *Striated.* It is somewhat darker and considerably more fragile than the deposit obtained in the case of the meta isomer of the above compound.

99. Nitro-diphenyl ether, para, saturated solution.

The deposit from this bath was not striated but resembled the *Control* in every respect and was so classed.

100. Nitro-para- amino-meta-diphenyl ether, saturated solution.

The compound was practically insoluble and the deposit resembled the *Control.*

101. Nitro-toluene, para, saturated solution.

This compound was only slightly soluble and gave a deposit resembling the *Control.*

102. Nitro-phenylacetic acid, para, saturated solution.

The deposit from this bath was rather dark in color and quite *Striated;* the striations being extended beyond the edge of the electrode by trees.

103. Oxalic acid, saturated solution.

The deposit from this bath resembled the *Control.*

104. Orange II, saturated solution.

The deposit from this bath also resembled the *Control.*

105. Orthochrome T bromide, saturated solution.

This bath also gave a deposit classed as a *Control.*

106. Pectin, saturated solution.

This bath also gave a deposit classed as a *Control.*

107. Phenol, 0.014M.

The deposit from this bath had the appearance of a *Control.*

108. Phenolphthalein, saturated solution.

Here also the deposit had the appearance of the *Control.*

109. Phthalimide, saturated solution.

The above compound was slightly soluble and the deposit had the general appearance of the *Control.*

110. Phenol Red, saturated solution.

The deposit from this bath was more *Coarse* than the controls and consisted of small, flaky, non-adherent crystals of lead.

111. Picric acid, saturated solution.

The deposit from this bath was brown in color, very adherent, almost non-treeing, and was very markedly *Striated.*

112. Propionic acid, 0.014M.

The deposit from this bath had the appearance of the *Control.*

113. Propylene glycol, 0.01M.

The deposit from this bath had the appearance of the *Control.*

114. Phenyl methyl pyrazolene, saturated solution.

This deposit had the appearance of the *Control.*

115. Pyridine, 0.014M.

The deposit from this bath had the appearance of the *Control.*

116. Pyrimidine, oxyhydroxy.

The deposit obtained from this bath had the appearance of the *Control.*

117. Pyruvic acid, 0.014M.

The deposit obtained from this bath had the appearance of the *Control.*

118. Quinhydrone, 0.014M.

The deposit obtained from this bath was darker than the control, slightly *Striated* and appreciably treed.

119. Quinine sulfate, saturated solution.

The deposit obtained from this bath had the appearance of the *Control.*

120. Quinone, saturated solution.

The deposit obtained from this bath was somewhat darker in color than the controls and slightly *Striated.*

121. Rosolic acid, saturated solution.

The deposit from this bath had the appearance of the *Control.*

122. Rosin, saturated solution.

In this instance no noticeable amount of the addition agent dissolved and the deposit obtained resembled the *Control.*

123. Salicylic acid, saturated solution.

The deposit from this bath had the appearance of the *Control.*

124. Saponin, 0.1%.

The deposit from this bath was *Intermediate* in texture, considerably darker than the controls, and was treed slightly around the edges of the electrode.

125. Hippuric acid, 0.014M.

The deposit from this bath treed considerably, was somewhat darker than the *Control,* but was slightly finer in texture. H owever, it was not considered fine enough to be classed as an intermediate deposit.

126. Sodium oleate, saturated solution.

The deposit obtained from this bath was somewhat finer than the controls, darker in color, and had a greater amount of treeing on the edges of the cathodes. *Intermediate.*

127. Sodium nucleinate, saturated solution.

The deposit from this bath had a *Fine* texture and a light grey color. There was an excessive amount of dark, leafy, almost amorphous trees around the edges of the electrode. These trees were so fragile that the cathode was not washed for fear of losing them.

128. Sodium, para-nitro, phenyl diazotate (anti), saturated solution.

The deposit from this bath had the appearance of the *Control* and was classed as such.

129. Sodium valerianate, saturated solution.

The deposit from this bath had the appearance of the *Control.*

130. Silver nucleinate, 0.1%.

The deposit from this bath was *Fine* in texture, fairly bright in color, and was only slightly treed.

131. Silver proteinate, saturated solution.

The deposit was *Fine* in texture, light grey in color, and slightly treed around the edges of the cathode. This deposit is very similar to the deposit obtained in No. 130.

132. Nucleinic acid, saturated solution. *Fine.*

The deposit from this bath was very similar to the one obtained for sodium nucleinate, both as to texture, coloring, and treeing.

133. Stearic acid, saturated solution.

The deposit from this bath resembled the *Control* in every respect.

134. Succinic acid, saturated solution.

The deposit from this bath resembled the *Control.*

136. Sulfanilic acid, saturated solution.

The deposit from this bath was *Intermediate* in texture, rather bright in appearance, and was treed somewhat more than average around the edges of the electrode.

137. Tannic acid, 0.1%.

The deposit from this bath was *Abnormal* in appearance; it was very similar to the deposit obtained from arsanilic acid.

138. Tartaric acid, 0.014M.

The deposit from this bath was very similar to the *Control.*

139. Thiourea, saturated solution.

The deposit from this bath was *Intermediate* in texture, grey in color, with some treeing around the edges of the electrode.

140. Thiazolidone, saturated solution. *Intermediate.*

The deposit obtained from this bath was very similar to the one just described above.

141. 3-para tol, 2-para tolimino thiazolidine, saturated solution.

The deposit obtained from this bath was similar to the *Control.*

142. Tolyl glycine ester, saturated solution.

The deposit obtained from this bath was similar to the *Control.*

143. Triphenyl guanidine, saturated solution.

This deposit also was classified as a *Control.*

144. Urea, 0.014M.

This deposit had the characteristics of the *Control.*

145. Vanillin, 0.1%.

The deposit from this bath was of the same type as the control but considerably more *Coarse*

146. Aluminum nitrate, 0.014M.

This deposit had the characteristics of the *Control.*

147. Ammonium fluroide, 0.014M.

On the addition of the above compound to the stock solution a precipitate of lead fluoride was formed. This precipitate was filtered before electrodeposition was begun. The deposit had the appearance of the controls and was classed as a *Control.*

148. Ammonium nitrate, 0.014M.

The deposit had the appearance of the *Control.*

149. Barium nitrate, 0.014M.

The deposit had the appearance of the *Control.*

150. Bismuth nitrate, 0.014M. *Striated.*

On the addition of the above compound to the stock solution a precipitate of the sub-nitrate was formed. Electrolysis of the filtered solution gave a deposit which was deep grey in color, slightly treed around the edges of the cathode, striations were partially covered with a secondary deposit of lead.

151. Cadmium nitrate, 0.014M.

The deposit had the appearance of the *Control.*

152. Calcium nitrate, 0.014M.

The deposit had the appearance of the *Control.*

153. Cerium nitrate, 0.014M.

The deposit had the appearance of the *Control.*

154. Chromium nitrate, 0.014M.

The deposit obtained from this bath resembled the *Control.*

155. Cobalt nitrate, 0.014M.

The deposit obtained from this bath resembled the *Control.*

156. Copper (ic) nitrate, 0.014M.

The deposit from this bath was *Intermediate* in texture, copperish in color, and not treed to any noticeable extent.

157. Ferric nitrate, 0.014M.

The deposit from this bath was identical with the *Control* except for the fact that some iron was apparently deposited with the lead.

158. Ferrous sulfate, 0.014M.

On the addition of the above compound to the stock solution a precipitate of lead sulfate was formed. The filtered solution gave a deposit comparable with the *Control.*

159. Lithium nitrate, 0.014M.

The deposit from this bath had all the characteristics of the *Control.*

160. Magnesium nitrate, 0.014M.

The deposit from this bath also had all the characteristics of the *Control.*

161. Mercurous nitrate, saturated solution. *Control.*

On the addition of the above compound to the stock solution a white precipitate was formed. The filtered solution gave a deposit comparable with the controls.

162. Mercuric nitrate, saturated solution.

The deposit from this bath was dark in color, *Striated,* and considerably more coarse than the controls.

163. Nickel nitrate, 0.014M.

The deposit from this bath had all the characteristics of the *Control.*

164. Potassium nitrate, 0.014M.

The deposit from this bath had all the characteristics of the *Control.*

165. Potassium permanganate, 0.014M.

The deposit from this bath was brown in color, *Intermediate* in texture, and treed considerably around the edges of the electrode. The trees were apparently amorphous in nature and very fragile.

166. Silver nitrate, 0.014M.

The deposit from this bath was *Coarse* in texture, black in color, and very soft.

167. Sodium acetate, 0.014M.

The deposit from this bath had all the characteristics of the *Control.*

168. Sodium bromate, saturated solution.

The deposit from this bath had all the characteristics of the *Control.*

169. Sodium chlorate, 0.014M.

The deposit from this bath had all the characteristics of the *Control.*

170. Sodium hydrogen arsenite, saturated solution.

The deposit from this bath was *Abnormal* in appearance, and non-adherent.

The deposit closely resembled that obtained from the arsanilic acid bath.

171. Sodium nitrate, 0.014M.

The deposit from this bath closely resembled the *Control.*

172. Strontium nitrate, 0.014M.

The deposit from this bath closely resembled the *Control.*

173. Thorium nitrate, 0.014M.

The deposit from this bath closely resembled the *Control.*

174. Uranyl nitrate, 0.014M.

The deposit from this bath was *Striated,* rather dark in color, and quite coarse; the treeing was not excessive.

175. Zinc nitrate, 0.014M.

The deposit from this bath closely resembled the *Control.*

176. Methyl-meta-benzaldehyde, saturated solution.

The deposit from this bath closely resembled the *Control.*

177. 2-methyl, 2,5,6, tri-nitro, 4, tertiary butyl phenol, saturated solution.

The deposit from this bath closely resembled the *Control.*

178. Para-hydroxy benzoic acid, 0.014M.

The deposit from this bath closely resembled the *Control.*

179. Methylamine hydrochloride, 0.014M.

The deposit from this bath was a deep grey in color but had the texture of the *Control.*

180. Ortho-cresol sulphonphthalein, saturated solution.

The deposit obtained from this bath was very light and was classed as *Abnormal,* the face of the electrode being covered with fragile leafy trees of lead.

181. Malachite Green, saturated solution.

The deposit obtained from this bath was *Intermediate* in texture, fairly light in color, but was treed on the edges of the electrode.

182. Ortho-hydroxy-tol-anilid, saturated solution.

The deposit from this bath closely resembled the *Control.*

183. Hexamethylene tetramine chloro-benzoylate, saturated solution.

The deposit from this bath closely resembled the *Control*

184. 2, iodo, 4 methyl aniline hydrochloride, 0.014M.

The deposit from this bath was *Intermediate* in texture, quite light in color, and had practically no trees.

185. Thymol sulfonphthalein, saturated solution.

The deposit from this bath was dark in color, granular in texture (*control*) and had little treeing.

186. Tetra bromo, cresol-sulfonphthalein, meta. saturated solution.

Abnormal. The deposit obtained from this bath was the most unusual deposit encountered in this research. While in the bath the deposit extended some two centimeters out from the face of the electrode; on removal from the bath the deposit collapsed on the face of the electrode and had the appearance of tin foil. See Fig 1. The reverse side of the cathode was almost entirely free of electrodeposited lead. The deposits from the arsanilic acid baths were somewhat darker and not as tenacious but similar in all other respects.

187. Ortho-cresol phthalein, saturated solution.

The deposit obtained from this bath was very similar to the *Control.*

188. Pinacyanol chloride, saturated solution.

The deposit from this bath was rather dark in appearance and *Abnormal* with respect to the deposit. The face of the electrode was covered with small flakey trees and was rather dark in color.

189. Di-chloro-phenolsulfonphthalein, saturated solution.

The deposit obtained from this bath was bright in color and noticeably *Striated* with needle-like trees formed along the sides of the electrode.

190. Hydrazobenzene, saturated solution.

The deposit obtained from this bath resembled the *Control.*

191. Five iodo, hydroxy benzaldehyde, saturated solution.

The deposit obtained from this bath was similar to the *Control.*

192. Para methyl, ortho-iodo, benzanilid, saturated solution.

The deposit obtained from this bath was similar to the *Control.*

193. Nitro propane, 1., 0.014M.

The deposit obtained from this bath was darker than the controls and somewhat more coarse but was classed as a *Control.*

194. Alpha nitro-naphthalene, saturated solution.

The deposit obtained from this bath was similar to the *Control.*

195. One nitro, 2 hydroxy, naphthalene, saturated solution.

Control. The deposit obtained from this bath was very similar to the deposit obtained from the nitro propane bath.

196. One nitro, 2 amino-naphthalene, saturated solution.

The deposit obtained from this bath was slightly finer than the deposit obtained in No. 195 but was classed as a *Control.*

DISCUSSION OF RESULTS

Classification of the foregoing experimental data shows that the 196 deposits can be classified as follows:

Fine	5
Intermediate	27
Control	127
Coarse	8
Abnormal	9
Striated	20
	196

The above results tend to confirm the well-known fact that lead does not readily lend itself to smooth electrodeposition. Of the five deposits classified as *Fine,* only three addition agents (Brom Cresol Purple, silver nucleinate, and silver proteniate) gave deposits that were both fine in texture and showed no treeing. Although the above compounds may have been in the colloidal state in the baths, they were not alone in this respect, since a considerable number of other addition agents used were also colloidal in nature. The two types of compounds giving *Fine* deposits are unrelated in their chemical structure, one being a sulphonphthalein dye and the other being silver protein complexes. These facts leave as the most possible explanation the preferential absorption of these compounds by the small crystals of lead first formed on the cathode.[6]

It is also of interest to compare the effects produced by addition agents in

the case of lead with similar data in the case of silver determined in this laboratory.[4] In the case of silver, sixty per cent of the added substances produced some change in the form of the deposit; in contrast to this relatively large proportion, only thirty-five per cent of the addition agents tried produced some difference of form in the electro-deposits of lead. In the case of silver, organic acids were usually effective in producing smooth deposits; in the case of lead, such substances produced little effect. In the case of very abnormal deposits (as illustrated in Fig. 1), the effect was produced by tetrabrom cresol-sulfonphthalein when added to lead baths; somewhat similar deposits were produced in the case of silver when dimethyl gloxime was added to silver nitrate. In general then, there is no similarity in the effects of addition agents when employed in lead baths and when used in silver baths. This dissimilarity of effect is again strongly suggestive that adsorption is responsible for the effects in all cases, for it has long been known that adsorption is a highly specific phenomenon, depending both upon the nature of the material being adsorbed and upon the adsorbing agent.

LITERATURE CITED

1. MATHERS and MCKINNEY, Am. Electrochem. Soc., 27, 131-140 (1915).
2. JARVIS and KERN, Columbia University School of Mines Quarterly, 30, 100 (1909).
3. FUSEYA and YUMATO, J. Soc. Chem. Ind. (Japan) 31, 331-42 (1928).
4. TAFT and HORSLEY, Trans. Electrochem. Soc., 44, 305-20 (1938).
5. E. B. ROSA, G. W. VINAL, and A. S. MCDANIEL, Reprint No. 195 (From Bulletin of the Bureau of Standards, Vol. 9) 1912.
6. See Taft and Horsley cited above and Taft, Trans. Electrochem. Soc. 63, 53 (1933) and Taft and Bingham, J. Phys. Chem., 36, 2338, (1932).

A Preliminary Report on the Insect Orders Found in Various Grassland Habitats in the Vicinity of Hays, Kansas*

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The purpose of this paper is to present some tentative results of entomological work done at Hays, Kansas during the year of 1941. The results obtained will be supplemented by future work. One of the newest fields in entomology is that of the ecological relationships of insects to the plants upon which they live. This field is of economic importance and reveals that insects are one of the most destructive competitors of livestock for our native range. The present study has been made to determine what insect groups attack our native vegetation and the relative abundance of each group.

RELATED STUDIES

The work on native grassland insects is limited, but the work that has been done is rather thorough. Wilbur (1936) found that grasshoppers destroy inflorescences of pasture grasses because they climb upward to escape heat. He also worked on grasshopper populations in the big bluestem region. Whelen (1927) found in the bunch grasses of eastern Kansas, eight orders of insects containing fifty-four species exclusive of *Hymenoptera*. Bragg (1939) working in northern Oklahoma found the saying "life on the edges" to be true, due to the fact that there is a greater variety of food and an overlapping of species in the area near the edges. Osborn (1939) has written an excellent book on meadow and pasture insects. Hayes (1927) found the most abundant order of the prairie to be *Hemiptera*.

King (1939) studied various insect forms of the soil and found that it included nearly all the grassland insects. Payne (1927), studying the physiological side of winter survival of insects, found that they became winter hardened much the same as do plants through a process of dehydration and reduction in the amount of freezable water.

Smith (1940) found the number of insects to be greatest in overgrazed areas, but that the number of species decreased. He found *Orthoptera* to be the dominant order. Corner (1938) found that insects of the orders *Homoptera, Orthoptera,* and *Lepidoptera* prefer overgrazed areas while other orders show no preference.

METHODS

The present problem was started January 20, 1941 by Harold Hopkins and later was carried on by Dr. R. E. Bugbee, C. Deyoe, and the author. Observations were made weekly to determine the amount of insect activity and the greenness of plants. On March 22 seven different plant habitats were chosen from which the weekly collections were made. The habitats selected were: short grass, non-grazed; short grass, moderately grazed; and short grass, overgrazed; little bluestem, moderately grazed; and little bluestem, non-

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grazed; big bluestem, moderately grazed; and big bluestem, non-grazed.

The habitats were sampled by making fifty sweeps with a 12 inch net with a handle 36 inches long. The sweeps were made close to the vegetation to increase the number of non-flying insects obtained and the collector walked into the wind to reduce the number that would be disturbed. DeLong (1932) has made note of the fact that there are many factors that reduce the accuracy of the sweep method. However, Gray (1933) believed that comparative results found were sufficiently accurate for ordinary purposes. These sweepings were continued until December 9, when the collections were discontinued because we had ceased to get specimens in the nets due to the extreme conditions of winter. We were, however, able to find insects in a dormant state in the surface debris.

RESULTS

Insect activity was obvious even in the winter months. On February 5, after a few warm days, grasshoppers (*Orthoptera*), leaf hoppers (*Cicadellidae*), cactus bugs (*Coreidae, Hemiptera*), cutworms, and a few other forms were active. On warm days slant-faced grasshopper nymphs could be found. It is probable that they remained in the same instar throughout the winter. In these months the most available food was little barley (*Hordeum pusillum*) and pepper grass (*Lepidium densiflorum*).

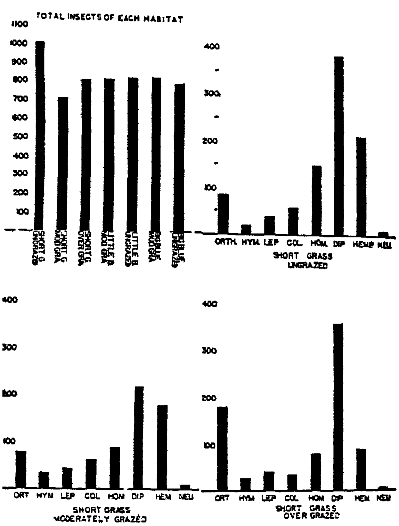

Fig 1

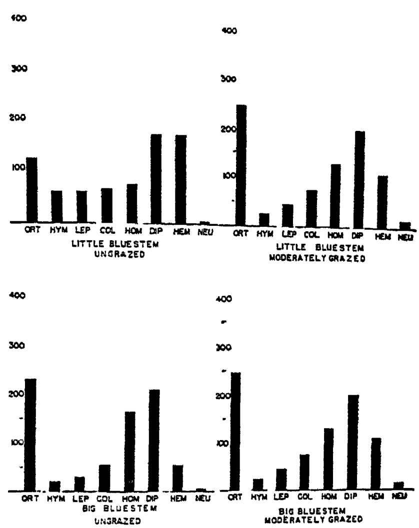

Fig 2

Figure 1 shows the total number of insects found in each habitat. The one important fact that it displays is that variation in the total number of insects taken from each habitat is only slight. The difference is in the type of insect found in each habitat rather than in the number.

In the short grass ungrazed habitat (Figure 1) the four most dominant orders were flies (*Diptera*), true bugs (*Hemiptera*), leaf hoppers (*Homop-*

tera), and grasshoppers (*Orthoptera*). However, in the short grass overgrazed area the grasshoppers rose to second in dominance. This habitat received severe treatment by the dust storms of the drought years and by overgrazing. C. C. Smith (1940), who worked in overgrazed areas in Oklahoma, states that: "Overgrazed pastures do not provide a favorable habitat for most birds and small mammals which normally utilize grasshoppers as a part of their food. . . . Reduction in fungus diseases would be expected since the shortgrass vegetation would allow rapid drying of the surface following rains. The greater amount of exposed soil surface is also an important factor favoring the breeding of most acridians." The order of dominance remains the same in the other two short grass habitats.

Grasshoppers, flies, and bugs are the three most dominant orders in the little bluestem habitats (Fig. 2). Grasshoppers are greater in number in the moderately grazed habitat than in the ungrazed habitat.

The most dominant order of the big bluestem habitats (Fig. 2) is *Orthoptera*. Next in the order of dominance are flies and then leaf hoppers.

The graphs of the individual orders (Figs. 3 and 4) show the month of the year when each group of insects is most abundant. The aphid lions (*Neuroptera*) were numerous in early spring, then decreased markedly, with a gradual increase until October when the first killing frost occurred. The presence of adult aphid lions early in the spring is attributed to those adults that hibernate during the winter then emerge in the spring to deposit their eggs. There were 15 taken in the net in March and 20 in October when they were most numerous.

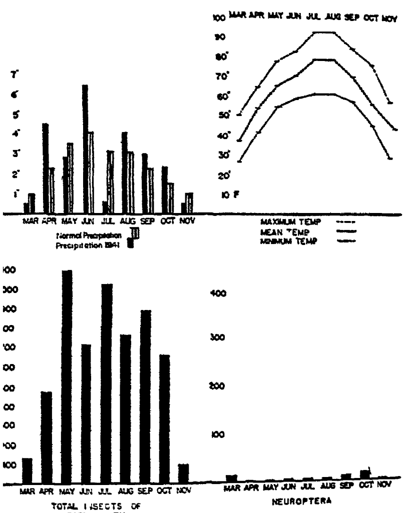

Fig 3

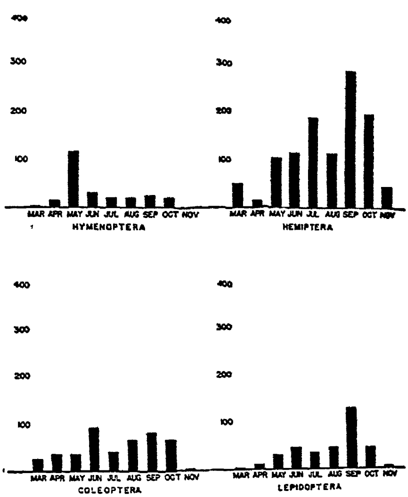

Fig 4

The grasshoppers made a gradual increase from spring until July, when they were most abundant. Three hundred and seventy-five grasshoppers were collected during the month of July; then there was a gradual decrease in the

number collected as winter conditions approached. All the grasshoppers taken were in the nymphal stage until June 19. The earliest adults were *Melanoplus mexicanus,* a small grasshopper commonly found in this region. A large percentage of the grasshoppers taken throughout the entire year were nymphs. When viewing the precipitation and temperature graphs (Fig. 3) it is noted that the maximum number of grasshoppers is reached in July, the hottest and dryest month of the year.

The number of wasps (*Hymenoptera*) increased slowly until the month of May, when there was an increase from 15 in April to 115 in May. This increase is attributed to the large number of parasitic *Hymenoptera* that emerge during the month of May. There was a definite drop in June to 30 insects. This abrupt drop may be partially due to the abnormally high precipitation, which caused a decrease in the temperature rise (see Fig. 3) which in turn would cause a decrease in the rate of emergence from pupae and eggs, and kill some adults. The number of *Hymenoptera* remains rather constant in the following months until October, the month of the first killing frost.

The numbers of leaf hoppers (*Homoptera*) follow a somewhat similar curve. There is a decrease in the month of June and a maximum in July.

Flies (*Diptera*) reach two climaxes—one in spring and one in the fall, with an extreme low in July, one of the hottest and dryest months. Our findings coincide with the statements of Hesse (1937) and others that as one proceeds northward *Diptera* become the most dominant group of insects.

The bugs (*Hemiptera*) reached a maximum number of 290 in the month of September, then decreased greatly in October and November.

The moths (*Lepidoptera*) are most numerous during the month of September. There is a gradual build-up in the number of moths during the summer months.

Beetles (*Coleoptera*) follow a rather uniform curve. Our data is probably an inaccurate sampling of the entire order of *Coleoptera,* since many families, such as the ground beetles and darkling beetles, are not often captured by sweeping. For the families that fly, however, such as the leaf beetles, we did get a representative sampling.

The greatest number of walking sticks (*Phasmatodea*) were captured in July, as would be expected since they are more numerous in southern regions.

The total of insects of each order that were obtained by sweeps throughout the year shows a predominance of *Diptera,* there being 1700 flies captured. Grasshoppers and true bugs, of which 1,000 of each order were obtained, ranked next in the order of dominance. There were 800 leaf hoppers and below them the sequence of dominance is as follows: beetles (*Coleoptera*), moths (*Lepidoptera*), aphid lions (*Neuroptera*), walking sticks (*Phasmatodea*), bark lice (*Corrodentia*), and dragon flies (*Odonata*).

The flies consisted primarily of three groups: Schizophorids (insects of the suborder Schizophora, families undetermined), which were by far the most abundant, syrphids (*Syrphidae*), and the robber flies (*Asilidae*). The syrphids and robber flies are considered beneficial because of their predacious habits.

The grasshoppers were mostly locusts (*Acrididae*), however there were a few coneheaded grasshoppers (*Tettigonidae*).

Of the true bugs the cactus bug and squash bug (*Coreidae*) were most numerous. There were also leaf bugs (*Miridae*), stink bugs (*Pentatomidae*), and asassin bugs (*Reduviidae*).

The most abundant family of the *Coleoptera* is the leaf beetle (*Chrysomelidae*). There were some blister beetles (*Meloidae*), snout beetles (*Curculionidae*), and lady beetles (*Coccinellidae*). Of these the lady beetles and blister beetles (in the larval stage) are beneficial.

The Lepidopterans were cutworm moths (*Noctuidae*) and measuring worm moths (*Geometridae*), both of which destroy vegetation.

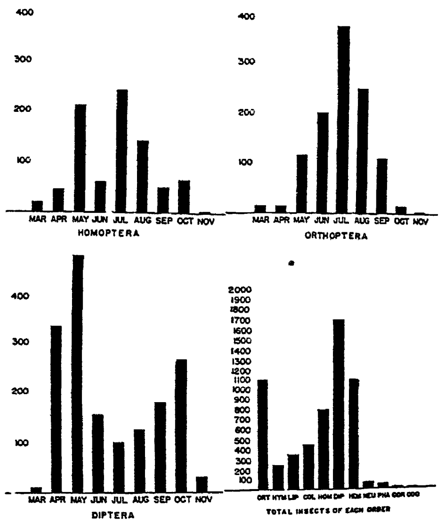

Fig 5

CONCLUSIONS

From the above results the following conclusions can be drawn:

1. Flies are the most abundant order in the short grass habitats and of the entire area near Hays, Kansas.
2. Grasshoppers, flies, and bugs are found in the little bluestem habitats.
3. Grasshoppers are the most dominant insects of the big bluestem habitat.
4. There is a correlation between insect populations and moisture-temperature relations.
5. There is an increase in grasshoppers in the areas that are grazed most heavily.

BIBLIOGRAPHY

1. Bragg, J. J. The geographic distribution of *Acrididae* in northern Oklahoma. Amer. Midland Nat., Vol. 22, No. 3, p. 660-675, Nov. 1939.
2. Coyner, W. R. Insect distribution and seasonal succession in overgrazed and normal grasslands. Thesis, Uni. of Okla., 78. 1938.

3. DeLong, Dwight M. Some problems encountered in the estimation of insect populations by the sweeping method. Ann. Ent. Soc. of Am., Vol. XXV, No. 1, p. 13-17, March, 1932.
4. Flint, W. P. and C. L. Metcalf. Fundamentals of insect life. McGraw-Hill Book Co., Inc., New York, 1932.
5. Gray, H. E. On the enumeration of insect populations by the method of net collecting. Eco. Vol. XIV, No. 4. Oct. 1933.
6. Hayes, W. P. Prairie insects. Ecol. Vol. VIII, No. 5, p. 238-250, April, 1937.
7. Hesse, Richard. *Ecological Animal Geography.* John Wiley & Sons, 1937.
8. King, Kenneth M. Population studies of soil insects. Ecol. Mono. Vol. 9, No. 3, p. 270-286, July, 1939.
9. Osborn, Herbert. *Meadow and Pasture Insects.* pp. 288. 1939.
10. Payne, Nellie M. Freezing and survival of insects at low temperature. Jour. of Morph. and Phys., Vol. 2, No. 2, p. 521-46, Mar., 1927.
11. Smith, C. C. The effect of overgrazing on the biota of the mixed grass prairie of Oklahoma. Ecol., Vol. 21, No. 3, p. 381-97, July, 1940.
12. Whelan, Don B. The winter fauna of the bunch grass of eastern Kansas. Ecol., Vol. 8, No. 1, p. 94-97, Jan., 1927.
13. Wilbur, Donald A. and Fritz, R. F. Grasshopper populations (*Orthoptera-Acrididae*) of typical pastures of the bluestem areas regions of Kansas. Jour. of Kans. Ent. Soc., Vol. 13, No. 3, p. 86-100, July, 1940.
14. Wilbur, Donald A. Grasshopper injury to the inflorescence of prairie grasses. Jour. of Kans. Ent. Soc., Vol. 9, No. 1, p. 12, Jan., 1936.

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Lepidoptera, Hemiptera and Homoptera Associated With Ironweed, Vernonia interior Small in Kansas*

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In order to obtain a knowledge of grassland insects, it is first necessary that the grassland complex be broken down to its individual plant units and the insect relationships to each unit be carefully ascertained. A study of the insects associated with ironweed, *Vernonia interior* Small of the composite family, has been conducted as a part of an investigation of insects associated with grasslands. A report on the 47 species of Coleoptera which were either feeding on some portion of the ironweed plant or utilizing its heavy foliage for shelter has been prepared (Schwitzgebel and Wilbur 1942). The following discussion concerns the relationship of 10 species of Lepidoptera, 25 species of Hemiptera and 33 species of Homoptera to the ironweed plant as observed from collections and field observations made approximately twice each week during the growing seasons of 1939-1941.

Ironweed observed in this study was found in several pastures near Manhattan in Riley County and near Wathena in Doniphan County. The plants varied from three to six feet in height in most environments. Their heavy foliage provided excellent shelter for insects during the hot periods of the summer. Ironweed is one of the most drouth resistant plants that can be found in Kansas grasslands.

All available stages of insect life were brought to the laboratory and attempts were made to rear the immature forms. For rearing such larvae as Arctiidae and Pterophoridae, plants growing at the insectary were caged with insects. A plot of ironweed at the insectary provided a source for food and oviposition for insects collected in the field and also attracted numerous insect species to the insectary.

An attempt to rear lepidopterous larvae in glass tumblers in which had been placed a quantity of soil was not successful because of the large loss from a fungus growth. Results were more satisfactory when cellucotton was substituted for soil. The larvae utilized cellucotton particles in making their cocoons. The cellucotton absorbed water readily, did not crust when dry and was easier to handle than soil. The loss from fungus was greatly reduced.

The roots, stems, leaves, and flower parts of ironweed were all subject to attack by lepidopterous insects. Larvae of the family Phaloniidae fed on the flowers, involucres, and seeds. One species of the family Pterophoridae, one of the family Arctiidae, and three undetermined species fed on the leaves of the plant. George P. Engelhardt has taken one Aegeriidae and one Noctuidae from burrows in stems of ironweed. Another Noctuidae was collected from

*Contribution No. 511 from the Department of Entomology, Kansas State College. This investigation was conducted in part in connection with project 211, Bankhead-Jones.

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its burrow in the stem. One species of Pyralididae burrowed in the crown and roots of the plant.

PTEROPHORIDAE

Oidaematophorus paleaceus Zell. This species of plume moth was collected and reared from *V. interior* in the Manhattan area. Fernald (1898) reported that this species, formerly placed in the genus *Pterophorus,* fed on *Vernonia noveboracensis* in Ohio, Illinois, Missouri, Texas, California, and Oregon.

Description. The light green eggs were discoid in shape and averaged 0.31 mm. wide, 0.47 mm. long, and 0.17 mm. thick. The white to light green larvae were subcylindrical, 9-12 mm. long, 1.5-2 mm. in diameter when mature, and covered dorsally with tufts of long hairs. The pupae were about the same size as mature larvae and became dull yellowish-brown just before emergence. Each pupa suspended itself from a leaf with its anal hooks attached to a mat of silk on the leaf. Fernald (1898) gave the following description of the adult: "Expanse of wings, 21-25 mm. Head yellowish-brown,—thorax dull yellowish-white. Abdomen dull yellowish, with fine longitudinal brownish lines . . . wings very pale brownish gray . . ." The specimens reared and collected in the vicinity of Manhattan had a wingspread of about 20 mm. The body was about 10 mm. long.

Injury to the plant. The larvae fed on the young terminal leaves of the plant from June until September. The extent of injury varied from complete skeletonization to partial consumption of the leaf and was confined to the terminal growth. The larvae were small and completed their life cycle within three weeks, requiring only a small amount of food. However, if the insect becomes as abundant in the field as it did in an experimental plot, serious injury to the plants can result. Young plants were brought from the field and transplanted in early June. By August the plants were only about half grown but the *O. paleaceus* larvae were so abundant that almost every leaf of each plant had been completely skeletonized.

Abundance. Adults were seldom seen in the field since they were nocturnal. The larvae were collected from June to September. There were fewer larvae during August than in June and July Seldom was more than one individual found on a single leaf but 10 to 15 larvae were collected from one plant on several occasions. More than 90 percent of the plants were attacked by the first and second generation larvae of the species in May and June 1941.

Life history. The generations of *O. paleaceus* overlapped to such a degree that it was difficult to determine the actual number. Rearing data and field observations indicated that four or five generations occurred. No overwintering form was found. About the first of June eggs were laid on the undersides of the young leaves adjacent to one of the larger veins. The newly hatched larvae fed close to the veins for several days before moving toward the margins of the leaf. In the field the larvae fed for the first three weeks in June before pupating.

Newly hatched larvae, presumably of the third generation, were collected during the second week in July and required from 8 to 11 days for feeding in the laboratory before pupating. The average duration of the pupal stage was 6.5 days with a range of 4 to 9 days. From two to three weeks were required for the completion of the life cycle in the laboratory.

Habits. According to Fernald (1898) "the adults usually fly on warm, calm evenings, and are occasionally attracted to lights but rarely to sugar. In the daytime they may be flushed from the plants but they fly only a short distance and alight. When at rest they hold their wings nearly horizontal and at right angles with the body, but the plumes of the hind wings are folded over each other and drawn under the forewings."

Predatism and Parasitism. Fernald (1898) stated the probability that the plume moths were preyed upon by birds. At Manhattan, feces were observed frequently on leaves of *V. interior* where *paleaceus* larvae were feeding, suggesting that birds utilized these larvae as food.

Seven hymenopterous parasites of the following three species were reared from the larvae: *Catolaccus aeneoviridis* (Gir.) (Pteromalidae), *Elachertus* sp. (Eulopidae), and *Ceratosmicra paya* Burks (Chalcididae).

ARCTIIDAE

Estigmene acraea Drury. Description. The eggs of this moth were yellow, spheroid, and about 0.8 mm. in diameter. The larvae were variously marked with black, yellow, and gray depending on their stage of growth. The fully grown larvae were about two inches long. The cocoon was gray and appeared to be constructed with hairs shed by the pupating larva. The pupa was dark reddish brown. The female had white wings with black markings. The abdomen was orange with several series of black dots or bars. The male had orange metawings and sometimes parts or all of the mesowings were dull orange. Otherwise the two sexes were marked similarly.

Injury to Plant. These salt-marsh caterpillars fed on the leaves of the plant and were found in the field as early as May and as late as the first week in October. In the laboratory they consumed all of the leaf except the midrib or a few large veins. In the field where food was abundant, however, they seldom fed on more than the apical half of any one leaf, then going to other leaves or often to another plant for additional food. During its life cycle each individual required a large amount of food but there were too few specimens to bring about serious injury to the plants. This insect is not specific on ironweed but is known to feed on many other plants, both wild and cultivated (Metcalf and Flint, 1939).

Life history. There were two generations in the vicinity of Manhattan. The pupae overwintered in the ground. The moths emerged in the spring and eggs were deposited on the leaves of ironweed during the last half of May. Larvae became full grown by July and pupated in the soil. In the laboratory the average date of pupation was July 16 and the mean emergence date was July 30. The adults oviposited on flowers and leaves during the first week in August and the larvae hatched three or four days later. The larvae fed until the last of September before pupating for the winter.

PHALONIIDAE

Several adults of an unidentified species of the genus *Phalonia* were reared from ironweed flowers by S. C. Schell in Doniphan County, Kansas, in August and adults and larvae of the same species were collected from ironweed near Manhattan in May, July, and August. The moths were brownish gray and less than one centimeter in length. The larvae fed on the flowers, seeds, and involucres during July and August.

Phalonia rana Busck has been reported from ironweed according to Dr. A. B. Klots of the College of the City of New York, who made the determinations of certain of the lepidopterous material from Kansas ironweed, but the species concerned was not *rana*, rather being nearer *aurorana* Kearfott or *zoxana* Kearfott.

AEGERIIDAE

Compositicola bassiformis (Wlk.). This insect was not found during this investigation, although, R. H. Painter and G. P. Engelhardt have taken this insect from *Vernonia* in Kansas.

Beutenmuller (1901) described the species and noted the following: Habitat: New York and Massachusetts, southward to Texas and westward to Nebraska and Colorado. A well marked species readily known by the gold bronze marking of the mesowings and by the bright yellow band on the abdomen. The larvae live in stems of trumpet weed, *Eupatorium purpurem*.

According to G. P. Engelhardt, this borer "resembles the larvae of *Pyrausta oxydalis* in color, makeup, and size and burrows in the same parts of the plant. It pupates within the gallery in a rough oblong cocoon of chips. The adults in the East emerge during August and early in September; in Kansas perhaps a week or two earlier."

NOCTUIDAE

Papiapema cerrusata G. and R No. specimens were taken on ironweed during this study. According to G. P. Engelhardt: "This noctuid bores in the upper part of the stem, working downward gradually with openings at intervals for throwing out frass. They burrow to the crown or even beyond. Pupation during September takes place normally in surrounding soil. It is a typical noctuid larva with sparse hairs and faint lateral lines and scattered blackish spots, especially at the spiracles. Full grown larvae should be one and one-half or more inches in length."

PYRALIDIDAE

Pyrausta oxydalis Gn. Description. Eggs of this species were not found. The larva was whitish with a reddish brown head capsule, a fully grown individual being about 18 mm. long and 2 mm. in diameter. It had four pair of prolegs with conspicuous black crochets, which formed a complete rings. Only one adult was reared during this investigation. Others have been reared from roots of ironweed by G. P. Engelhardt.

Injury to plant. This borer fed in the crown and the roots of the plant. The maximum height to which it burrowed up the stem was one or two inches above the crown but most of its feeding took place in the underground stem and roots. The larvae were present in the stems as early as the first week in July and in the roots as late as the last week in May of the following year. Some burrows were about 10 to 12 inches long.

The detrimental effect of this injury to the crown and roots of the plant was not determined but it was thought to be a limiting factor to the development of new shoots from the root stalks in the spring.

Abundance. Only a limited population study was made but it was observed that there was much variation in the abundance of this species in different localities. In some pasture these borers were found in nearly every plant while in other places very few larvae could be found. Twenty-four borers

were found in the 128 stems examined during 1940. Only one insect was found in any one stem.

Life history. By tracing the burrow of a young larva it appeared that the egg was laid on the outside of the stem just above the surface of the ground. Young larvae were found near the crown in July. During the growing season most of the feeding of the borers took place near the crown. Toward the end of the summer they cut almost through the stem just above the crown to provide an emergence hole for adults to escape in the following June.

In late autumn as the borer worked its way toward the roots, it constructed several plugs across its burrow, walling itself off from the crown above it. Feeding was resumed in the spring in the roots and pupation and emergence occurred in June.

Predatism. Ground beetle larvae were found several times in the burrows of this species with the remains of their prey. The species of the predator was not determined.

OTHER LEPIDOPTEROUS LARVAE

Three other species of lepidopterous larvae were observed feeding on ironweed leaves during the summer but adults were not reared. One was a brown humped-back worm more than an inch long with a distinct V.-shaped marking on the thoracic tergum. Another was a slender green leaf-roller about an inch long. The third was a yellowish brown larva with brown markings about three-fourths inch long.

APHIDIDAE

Two species of aphids were found on ironweed. *Aphis vernoniae* Thomas occurred on buds, petioles, leaves and stems while *Prociphilus* sp. were taken from roots and stems just below the crown

Aphis vernoniae Thomas. These bright yellow aphids were collected from ironweed during July and August. Sanborn (1904) found this species on *Vernonia* in July and indicated that it was gregarious and colonized on the terminal growth.

The following species of ants were found in association with *A. vernoniae*: *Cremastogaster opaca punctulata* Em , *C. lineolata subopaca* Em., *Cremastogaster* sp., *Dorymymex* sp., *Leptothorax pergandei* Em., and *Prenolepis imparis* (Say).

Prociphilus sp. Nymphs of this species were collected from the roots of ironweed in late August and in September, 1939, and in April, 1940. They were dingy white in color and their passageways in the soil were lined with powdery material. No winged forms were collected, hence the species could not be identified. According to Dr. F. M. Wadley who examined the aphids, *P. erigeronensis* Thomas would be expected to be found on the roots of composites in Kansas but the *Prociphilus* in question was not *erigeronensis*.

Dr. E. M. Patch, in her *Food-plant Catalogue of Aphids of the World* (1938), has listed nine species of aphids that have been taken from *Vernonia* spp.

MEMBRACIDAE

Micrutalis calva (Say). This small green membracid with a shiny black pronotum was collected in limited numbers from ironweed near Manhattan during the summer months. S. C. Schell reared a number of nymphs on *V.*

interior and reported that in Doniphan County, Kansas, the species was so numerous that injury to ironweed occurred.

Collections of adults and nymphs indicated that there were at least two generations each year. Adults of its first generation appeared about the middle of July while second generation adults were present during late August and early September.

CERCOPIDAE

Aphrophora quadrinota Say. Nymphs of this spittle bug were observed on ironweed during May and early June. They were found in masses of spittle on the stem several inches above the surface of the ground. The determination was made from the nymphs.

The following list includes those Hemiptera and Homoptera collected from ironweed. Several are known to be predators; others were utilizing the protective foliage of the plant, while the association of the other species to ironweed is not known.

A List of Hemiptera and Homoptera Collected From *V. interior*

Family Species	Collection Period	Total Specimens
Cydnidae		
Galgupha ovalis Huss.	July	1
Pentatomidae		
Homaemus bijugis Uhl	July	1
Podisus maculiventris (Say)	July	1
Thyanta custator (F.)	July-Aug.	5
Thyanta accerra Mc. A.	May, Aug.	2
Coreidae		
Coriscus pilosulus (H. S.)	July	1
Corizus hyalinus (F.)	Aug.	3
Corizus hyalinus var.	Aug.	7
Lygaeidae		
Blissus leucopterus Say	May, Aug.-Sept.	23
Lygaeus kalmii Stal.	May-June	3
Nysius ericae (Schill.)	June	1
Orthaea basalis (Dall.)	July	1
Reduviidae		
Aristus cristatus Linn.	July	1
Sinea diadema Fab.	July-Aug.	3
Nabidae		
Nabis alternatus Parsh.	June	1
Anthocoridae		
Orius insidiosus (Say)	Aug.-Sept.	11
Miridae		
Adelphocoris rapidus Ku.	July-Aug.	11
Ceratocapsus fuscosignatus Kn.	July	7
Horcias dislocatus nigritus Reut.	May	1
Lygus pratensis (Linn.)	July-Aug.	14
Melanotrichus coagulatus (Uhl.)	May	1
Polymerus basalis (Reut.)	July-Aug.	2
Psallus seriatus (Reut)	May	1
Neididae		
Jalysus spinosus (Say)	May	1
Piesmidae		
Piesma cinerea (Say)	May, July	31
Cicadidae		
Melampsalta calliope (Walk.)	July	1

Family Species	Collection Period	Total Specimens
Membracidae		
Ceresa bubalus (F.)	Aug.	3
Campylenchia latipes (Say)	July-Aug.	4
Stictocephala inermis (F.)	July-Aug.	9
Cercopidae		
Lepyronia gibbosa Ball	July	5
Fulgoridae		
Oliarus aridus Ball	July-Aug.	6
Cixius stigmatus (Say)	May	1
Araeopidae		
Delphacodes sp.	July	1
Cicadellidae		
Aceratogallia sanguinolenta (Prov.)	July-Aug.	2
A. uhleri (V.D.)	July	18
Cicadella hieroglyphica (Say)	May, July	3
Draeculacephala mollipes Say	May, July	3
Platymoides acutus (Say)	July	5
P. cinereus (O & B.)	July	3
Nasutoideus frontalis (V.D.)	May, July, Aug.	5
Polyamia inimicus (Say)	May, July	55
Laevicephalus minimus (O & B.)	July	1
L. spicatus De L.	May	3
L. striatus (L)	May, July	2
L. collinus (Sahlb.)	May	1
Exitianus obscurinervis (Stal)	July	7
Novellina chenopodium (Osb.)	July-Aug.	3
N. seminudus (Say)	Aug.	3
Macrosteles divisus (Uhl.)	May, July	17
Mesamia coloradensis (G. & B.)	June	1
Phlepsius irroratus Say	Aug.	1
Balclutha abdominalis (V.D.)	May, Sept.	15
Erythroneura sp., obliqua group	Aug.	1
E. sp., obliqua group	Aug.	2
E. sp., obliqua group	Aug.	1
Hymetta balteata Mc. A.		1
Empoasca fabae (Harr.)	May	9
E. decurvata D. and DeL.	July	30

Identifications were made by the following specialists: Lepidoptera by Carl Heinrich and A. B. Klots; Hemiptera by H. G. Barber; Cercopidae by K. C. Doering; Aphididae by F. M. Wadley; Cicadellidae by P. W. Oman and D. A. Wilbur.

SUMMARY

1. Ten species of Lepidoptera associated with ironweed are discussed. The following species were observed feeding on the plant near Manhattan, Kansas: *Oidaematophorus paleaceus* Zell. (Pterophoridae) feeding on leaves; *Estigmene acraea* Drury (Arctiidae) feeding on leaves; *Phalonia* sp. (Phaloniidae) from flowers; *Pyrausta ozydalis* Gn. (Pyralididae) boring in crowns and roots; three species (unidentified) feeding on leaves.

2. *Aphis vernoniae* Thomas were collected from the terminal growth while *Prociphilus* sp. were found in the roots.

3. *Micrutalis calva* (Say) of the Membracidae were reared from ironweed as were *Aphrophora quadrinota* Say (Cercopidae).

4. A list of 58 species of Hemiptera and Homoptera, collected from ironweed but whose relationships to the plant are not known, is included.

LITERATURE CITED

BEUTENMULLER, WM. Monograph of Sesiidae of America north of Mexico. Amer. Mus. Nat. Hist. Mem. 1(6):284-285, 1901.

FERNALD, C. H. Pterophoridae of North America. Mass. Agr. Col. Spec. Bul. 62 p. 1898.

METCALF, C. L. and W. P. FLINT. Destructive and useful insects, their habits and control. New York, McGraw-Hill. 1939.

PATCH, E. M. Food-plant catalog of aphids of the world. Maine Agr. Expt. Sta. Bul. 393, 1938.

SANBORN, C. E. Kansas Aphididae with catalog of North American Aphididae. Kansas Univ. Sci. Bul. 3(1):57-58, 1904.

SCHWITZGEBEL, R. B. and D. A. WILBUR. Coleoptera associated with ironweed, *Vernonia interior* Small in Kansas. Jour. Kans. Ent. Soc. 15(2): 37-44, 1942.

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The Eleventh Annual Insect Population Summary of Kansas—1941[1]

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This summary is prepared from information supplied largely by the same persons using the same type score sheets as were used for the 1940 summary. Three hundred and ten questionnaires originating as shown in Table 1 were summarized for Table 3.

TABLE 1. SOURCE OF QUESTIONNAIRES RETURNED AND SUMMARIZED FOR THIS REPORT.

		No. in July	No. in October
Group 1.	Entomologists in the state	15	17
Group 2.	County Agricultural Agents	69	69
Group 3.	Farmers, mostly college graduates	24	20
Group 4.	Vocational Agricultural Teachers	67	29
	Total reports of each group	175	135
Grand total of all questionnaires summarized for this report		310	

SUMMARY OF WEATHER CONDITIONS IN KANSAS BY MONTHS FOR 1941.[2]

January was the third wettest on record, 15 days being cloudy and 5 partly cloudy. There was more cloudiness than in any previous January save one. The mean temperature for the month was 3.5° above normal, with no excessively cold weather.

February was characterized by continued, unusual cloudiness, but precipitation was below normal for the state as a whole. Heavy snowfall occurred during the latter third of the month in the central part of the state, and in some western counties.

March temperatures were below normal. Although average precipitation was considerably below normal, heavy snows occurred and cloudiness was excessive.

April was one of the wettest on record, and rainfall occurred more frequently than in any previous April for which data are available. Except in the extreme west, temperatures were above normal. Cloudiness was considerably greater than normal. Wheat made a remarkable growth.

May was a good month for crop development, with a mean temperature well above normal. Rainfall was only slightly below normal, and sunshine was adequate. Heavy downpours were beginning in the southeastern counties as the month ended.

*Contribution No. 510, Department of Entomology.

[1]This report includes results obtained on Project No. 6 of the Agricultural Experiment Station. Recognition for assistance is due the Extension Entomologist, Dr. E. G. Kelly, for supplying information and for sending the questionnaires to the county agents; to colleagues for reporting observations for this summary; and to all those returning the score sheets.

For other summaries in this series, see the *Journal of the Kansas Entomological Society* for the summaries for 1931 (vol. 5); 1932 (vol. 6); 1933 (vol. 7); 1936 (vol. 10); 1937 (vol. 11), and 1939 (vol. 13) and the *Transactions of the Kansas Academy of Science* for 1934 (vol. 38); 1935 (vol. 39); 1938 (vol. 42), and 1940 (vol. 44).

[2]Based largely on Climatological Data, Kansas Section, by S. D. Flora. U. S Dept. Agr. Weather Bureau, v. 55,1941.

Transactions Kansas Academy of Science, Vol. 45, 1942.

June was characterized by the heaviest precipitation since 1928, and was the fifth wettest on record. In the western third of the state, it was the wettest on record. Most rivers overflowed. Temperatures were somewhat variable, averaging slightly below normal. Cloudiness was greater than usual. Harvesting was hampered by unfavorable field and weather conditions.

July had rainfall slightly below average, but was nevertheless the third wettest July since 1929. The western third of the state received almost twice as much rain as the eastern two-thirds. Temperatures were approximately normal. High relative humidity prevailed in the eastern part of the state during late July.

August precipitation and the mean temperature were above normal. High humidity in the eastern part of the state continued. It was an excellent month for crop development.

September was the fourth wettest on record. Although there was much cloudiness, temperatures were above normal until the closing days of the month, which were unusually cold, though no severe frosts occurred.

October was by far the wettest since state-wide records were begun in 1887. Cloudiness was excessive and temperatures were slightly above normal. Nearly all rivers overflowed during the month, causing an estimated total damage of $10,000,000. On the final day of the month, there was a heavy snowfall over most of the state.

November offered sharp contrast to the preceding month, with subnormal precipitation in most sections. The soil, however, remained wet from previous moisture. The weather was generally mild, with temperatures above normal. In the east, much wheat remained to be sown when the month ended.

December was exceptionally mild, especially in the first three weeks, with more precipitation than usual and an excessive amount of cloudiness. Snowfall was unusually heavy in the northern part of the state and wheat made a luxuriant growth. The year closed with sub-zero weather.

In general, 1941 was the second wettest since 1887, being exceeded only by 1915. Total rainfall is however misleading because the time and distribution of rains determine their influence on crops and insects. In 1941, the abnormally heavy rainfall of October had little influence on insects except to favor the development of Hessian fly. Floods in June and October, were more numerous in many rivers particularly the Neosho, Solomon, Republican, Blue and Kaw rivers causing more destruction than for many years. The total flood loss was the greatest on record. The temperatures of all winter and summer months were mild and there was an unusual amount of cloudiness. All winter months were above normal. June and July were below normal, with August a degree above normal.

It was a favorable year for crops though wheat harvest, wheat seeding and corn cribbing were hampered by rains and wet ground.

TABLE II. SUMMARY OF WEATHER DATA FOR THE STATE OF KANSAS FOR THE PERIOD SEPTEMBER 1, 1940 TO DECEMBER 31, 1941.

Month	Temperature in degrees Fahrenheit					Precipitation in inches					
	State Average	Maximum	Minimum	Average for 58 years	Departure from normal	State Average	Average for 58 years	Departure from normal	Eastern third	Middle third	Western third
September 1940	70.5°	102°	29°	69.8°	+0.7°	2.50	2.77	—0.27	2.64	3.06	1.81
October 1940	63.5°	93°	23°	57.3°	+6.2°	1.05	1.88	—0.83	1.61	1.07	0.46
November 1940	40.4°	86°	—19°	43.2°	—2.8°	2.66	1.29	+1.37	3.44	2.96	1.57
December 1940	36.5°	77°	—14°	33.1°	+3.4°	1.02	0.84	+0.18	1.39	1.09	0.58
January 1941	33.3°	70°	—7°	29.8°	+3.5°	1.99	0.70	+1.29	3.55	1.40	1.02
February 1941	34 1°	72°	—2°	33.0°	+1.1°	0.77	0.99	—0.22	0 54	0.98	0.80
March 1941	40.4°	81°	10°	43.4°	—3.0°	0.90	2.16	—0.53	0.93	0.99	0.78
April 1941	56.3°	86°	21°	54.8°	+1.5°	3.22	2.54	+0.68	4 36	2.49	2.82
May 1941	67.9°	102°	35°	64.0°	+3.9°	3.54	3.82	—0.28	3.17	3 35	4 11
June 1941	72.1°	106°	41°	73.8°	—1.7°	6.35	4.01	+2.34	6.46	6.78	5.81
July 1941	79 0°	110°	51°	79.2°	—0.2°	3.05	3.13	—0.08	2.65	2 25	4 24
August 1941	78 6°	106°	44°	77 8°	+0.8°	3.86	3.14	+0.72	6 05	3.19	2.35
September 1941	71 0°	103°	32°	69.8°	+1.2°	4.76	2.80	+1.96	6.51	4.72	3.05
October 1941	58.4°	95°	20°	57.3°	+1.1°	6 51	1.97	+4.54	10.29	6.57	2.66
November, 1941	45.1°	87°	—4°	43.2°	+1.9°	0.88	1.29	—0.41	1.29	0.88	0.47
December 1941	37.8°	77°	—16°	33 2°	+4.6°	1.09	0.84	+0.25	1.48	1.08	0.71
Averages or totals for 1941	56.2°	110°	—16°	54.9°	+1.3°	36.92	26.61	+10.31	47.28	26.10	18.88

There is a discrepancy in the maximum temperature for August as reported in the monthly report which gave it as 110° and the Annual Report which recorded it at 106°.

CROP PRODUCTION SUMMARY FOR 1941.[3]

The year 1941 was generally favorable for crop production in Kansas despite losses as a result of heavy rains during the harvest season. Yields per acre for most crops in Kansas exceeded corresponding 1940 yields. The total harvested acreage for all crops was 22,313,000 in 1941, as compared with 19,885,000 in 1940, an increase of some 12 per cent.

The 173,332,000 bushels of wheat produced in 1941 constituted the largest crop since 1931, and the fourth largest in the history of the state. Only in the south central, northeast, east central, and a southeastern section of the state were total wheat yields less than in 1940, this reduction being the result of excessive wet weather, insect damage, and the extreme cold of Nov. 11, 1940, which caused winter killing.

The corn production in 1941 was 57,224,000 bushels, an increase of nearly 15,000,000 over 1940, but some 2,000,000 less than the average from 1930 to 1939.

Oats produced only 36,428,000 bushels in 1941, as compared with 46,710,000 in 1940; barley, however, rose from 18,176,000 to 26,120,00 bushels.

The 1941 grain sorghum crop of 24,55,000 bushels fell more than 3,500,000 bushels short of the 1940 figure. The forage sorghum production of 4,173,000 tons in 1941 represented an increase of nearly 570,000 tons over 1940.

Both wild and tame hay showed material increases in production over the 1940 figures. Alfalfa seed dropped from 154,000 bushels in 1940 to 138,000 bushels in 1940. The potato yield was slightly greater in 1941 than in the preceding year.

The severe storm of November 11, 1940, which killed a very large percentage of apple tres, was chiefly responsible for a drop in commercial apple production from 1,296,000 bushels in 1940, to 486,000 bushels in 1941. There was an even greater reduction in peaches and cherries and a corresponding reduction in berries for the same reason.

DESCRIPTIVE ACCOUNT OF THE MORE IMPORTANT INSECT ACTIVITIES AND CLIMATAL RELATIONSHIPS DURING 1941

Ants appeared to be slightly below normal in numbers and less annoying than in 1940. Winged ants were in flight March 21 in Riley County and tanglefoot bands on trees for canker worm moths caught many during March and up to mid-April. Kafir ants damaged kafir in Osage County the latter part of May and were frequently reported as house pests in Eastern Kansas. Swarming flights caused concern in October also. Roy Fritz reported that the mound building prairie ant (*Pogonomyrmex occidentalis*) caused considerable damage to all types of highways in western Kansas during the past few years. These ants damage the borders of concrete and oil mat types of highways to the extent of several thousands of dollars in maintenance and repair costs every year. Following every sizable rain, maintenance crews are busy for several days making fills in the gullies caused by water running off the highways over the bare nests on the shoulders. Many nests are built directly under the edge of the highway mat causing the surface to sink, crack and break. They also weaken and kill the grasses, shrubs, and trees with which

[3]From Kansas 1941 Crop Review, Kans. State Bd. of Agr., Agricultural Statistics Division, Dec. 23, 1941. Mimeographed Release.

TABLE III. Population summary of the more common and important insects in Kansas for 1941, as indicated by 310 questionnaire score sheets from all counties.

COUNTIES	ANTS-GENERAL	BAGWORM-Evergreen	BITING FLIES-Livestock	BLISTER BEETLES	BORES-Trees	BOT FLIES-Horses	CABBAGE WORMS	CANKER WORMS	CATTLE GRUBS	CHINCH BUGS	CODLING MOTH	CORN EAR WORMS	CUCUMBER BEETLES	CRICKETS	CUT WORMS	FALL ARMY WORM	FLEAS-Pets and Houses	FLEA BEETLES-Garden	GARDEN WEBWORM	GRAIN WEEVILS	GRASSHOPPERS	GREEN BUG-Wheat and Oats	HESSIAN FLY	HORSE FLY-Tabanidae	LEAF HOPPERS-Potatoes	LICE	MITES-Poultry	MOSQUITOES	PEA APHID-Alfalfa and Peas	POTATO BEETLE	ROSE SLUGS	SCREW WORMS	STRAWBERRY LEAFROLLER	TENT CATERPILLARS	TERMITES	TOMATO WORMS	WALNUT WORMS	WEBWORMS	WHEAT STRAW WORMS	WHITE GRUBS	WIREWORMS
ALLEN	2	3	2	2	3				2	3			3		2		2			3	3		4					4		2				2						3	
ANDERSON			2	2						2			3			3				3	2		3							2											
ATCHISON			4	2	2	2	3	3		4	4	3	3	3	2	2	3			4	3	1	4	2		2	3	3		4		2		2	3					2	2
BARBER			3	2	2	2		2	3						3					3	2					3	2	3	3	3	2				3			2		2	
BARTON			4	2		2	2	3	3			2	2	2	2					3	4		2	2				3	3	2		2			2	2					
BOURBON			2	3						3			4								3		3							2											
BROWN			3		3	2	3			3	3	3	2		2		2	2		2	3			4				2		3						3			2	3	
BUTLER				2	2		2	5		5								2	3	3	2	4	4							3		2									2
CHASE			3			2				4		2								2	3											3									
CHAUTAUQUA																					2																				
CHEROKEE	1	4	2	2	3	2				4			3	2	3		2			4	3			5	3			3		2			3	3	3				2	3	
CHEYENNE	2			3		3						3	2				3				4									2		3				2					
CLARK			2	3		2			2				2		2		2			3	3	2				2		2		2		3			4				2	2	
CLAY	2		3	3	3	2	4	3	2	4	2	2	3	3	2	2	2		2	4	3	3	5	3	2	4	3	2	2	4	3	2		2		2		3		3	2
CLOUD			3	2	2			3		3	2	3	2	3			2			3	3		4	3		2		3		3	4				3	3			3	2	
COFFEY		3	3	3	2	2			2	4		2	3		2				3	3	3		4				2	3				3								2	3
COMANCHE			3	2	2	2			3			2	2	2	3	3				3	3					2		1				2			2						
COWLEY	3		3	3	3	2	3	3	3	4	3	4	3	3	2	3	2	2	3	3	3	3	5	2	2	2	2	4	2	3		3		2	4	2	2	3	2	3	3
CRAWFORD	2		3	2	3	2				4		3	3	2	2		2	3		3	3		4	2				3	2	2				3	4		2		2		3
DECATUR			3			2							2		4			3		4	3															2			2	2	
DICKINSON	4	2	3	2	2	2		4		4			2	3				2		2	3		4	2				3		2	2	3			3					3	
DONIPHAN	2	3	3	3		3	3	2		3	4	3	3	2	2		3	3		4	3		3	3	3		4	4		3	3		4		4	2	3			3	3
DOUGLAS			3		2			3		2		2	4				3				2		4		2					3			3	2	2					3	
EDWARDS			2		2		3				2	3	2		2		2		2	2	3					2		3		4					2	3				2	
ELK			3	3	2	3			3	3	2		3							2	3		4			3	2		2	3	2				2			2			
ELLIS	2		3	2	3	2		4	3		2	2	2	2	4		3	2		2	4			3	2	2	2	3		4					3	3			2	2	2
ELLSWORTH	1		3	3		3		5	3				3		4	4		3		3	4					3		3	3	4					4	2			3	3	3
FINNEY			4	2	3	2	2					2	2	3	4			2	2	3	4				2			4	4	2		3			2	2		3		2	2
FORD			3			3															4																				
FRANKLIN			3	2	2	3		2		4	3	2	2		3		2			3	3		4	3		2	3	3		3	3	3			2	3	2	2		3	
GEARY	2		3	2		2		3	2	4			3	2			2			3	3	3	3	3				3		3		3			3	2				2	
GOVE																																									
GRAHAM				2	2															3	3																				
GRANT	3		5	2	3	2							4	4	4						4																				2
GRAY	2		3			2			2				2	2							4							2				3									2
GREELEY			5		2	2		2	3				3		5			3		3	4					3									2				3		
GREENWOOD			3		3	3				4			3	3			2			2	4		4	3				3		3					3					2	
HAMILTON			4	2		3									3			2			4							3		2											2
HARPER			2	2			3					3	2	3	3	2	2		2	3	2						2	2		2		3		1	2					2	
HARVEY	3		3	2	2	2	2	2	2	3			3	4	3		3	2		3	2	2	5	2	3		2	3	3	3	3		2	2	2				3	3	2
HASKELL			4			2			3						4		2			2	4				2			4			2				2			2			2
HODGEMAN			2	2														2		3	3							4											4	3	
JACKSON	3		3	1		2				4	2			3						3	3		4			3	2	3		3		3			3		2				
JEFFERSON	3		3	2	2	2		3	2	4			2	2	4		3			3	3	3	4	3	2			2	2	3		3	3		3						2
JEWELL			2	3		3		2	3				2		2					2	3		2	2			2	3		2					3						2
JOHNSON	2		3		2	2	2		3	2	3	2	3		2		2			2	2		3	2		3	2	3	3	4		5	2		3					2	2
KEARNEY	2		3			3						2								2	4							3	4												
KINGMAN			3	2	2	2			2	1			2		3			2		2	3			2		3	3	2		3			2							2	3
KIOWA			3	3		3			2		2	3	2	3	3					3	4			2			3	4		2		4			3					2	
LABETTE	2	4	2	3	3	3	3	5	3	5	4	3	3	2	3	2	2		2	3	3	4	5	3	2	2	3	4	2	3	3	1	2	3	3	2	3	4	2	3	3
LANE			2											2	3						3							2													
LEAVENWORTH	2	3				2					2			3		2	2											3				4									
LINCOLN			3					3							4						3									4											2
LINN			3	2	2	3	3	3	3	3	2	3	3		2		2	2		3	2		3	3		3	2	2		3	2	3			3		2		3		
LOGAN	2		5	2		2			3			3	2	2	4			2		3	5			3		3	2	3				5							2		
LYON	2		3	3		2		4	3	3		2	3	3			2			3	2		3			3		3		3		3		1						2	
McPHERSON	3		3		3	2		3	2	3	2		3	3	3		2	2		3	2	2	4	3		3		3		4	5		3	2	2		2			2	2
MARION			3	2						4					3								5												3						2
MARSHALL	2	2	3	2	2	3	2	2	2	4	2	3	2	3	3	2	3	2	2	3	3	2	4	2	2	3	3	3	2	3	3		2		4	3		2		2	2
MEADE			5	3	2	2			4				2		4		3	2		3		2		5		4	3	5	3	2	2				2			2	2		3
MIAMI																																									
MITCHELL				4		3		4	3				3							3	3			3				3		4					3						
MONTGOMERY		2	3	3	3	2		3	3	3	3	3	3	2	2	2	2	2	2	3	3	2	3	3	2	3		3	2	3	2		2	3	3					2	2
MORRIS			3		3	2	2	4	3	4	2	3	2		2	2				3	3		4	4			3			3		3			2						
MORTON			3																	1	5							3													
NEMAHA	2		3	2	2	2	3			3		3	2	3						3	3		4	2	4			3		3		3				3				3	
NEOSHO	3	5	3	3	4	2	3	2	2	3	3	3	3	3	2				2	3	3	2	4	2	2	2	3	4	2	3	3	2	2	3	3	2	2	2		2	3
NESS																					3														4						
NORTON	2		3	3	2	3	3	5	3			3	3	3	4			3		3	4			2	3		3	3		2		2			3				2	3	2
OSAGE	2		3		1	2			2	3		3	3				2			3	4		4	2		3	3	2		3		4			2						
OSBORNE	2		3	3	4	3	2	4	2			2	3	2	4	2		3	2	4	4	2		2		3	2	3	2	3		2	2		3	2		3		3	
OTTAWA			3			2		3	2		3		2	3	2					4			4			4		3		3					3				2		
PAWNEE			3	2	2	2		2			2	3	2	3				2		4	4	3				3		3	2	4			3		4	3				2	3
PHILLIPS	3		3	3				4	3			3	3		4			3		3	3				2			2	3	2				1	4	3				2	
POTTAWATOMIE	3		3	2		2	4		2	4			3	3	3				3	3	3	2	4	2				2		3					3			2	2		
PRATT			3	2		2							2		3					2	2	2		4				5	3	3					2						
RAWLINS			3	3	2	2	2		3				2							3	3				2		2	3		2						1					
RENO	2		3	2	3	2	4	4	2	2	2	2	3	2	3			2	2	2	3	3	2			3	3	3	2	4	1		2		2			2		2	2
REPUBLIC										4		2		2						2	2																				
RICE	2		3	2	2	2	3	4	2	2		2	2	4	4	3	3			3	3			2	2	3	2	3		3	3	2		2	2	3				2	2
RILEY	3		4	3	2	2	4	3	3	4	3	4	3	3	2		3			3	3	3	5	2	3		3	2	3	4	3		2	2	2	2			4	3	
ROOKS				3					2			3	3		4					3	4							2							3			2			
RUSH			3		2								2		4			3		3	4														3				2		
RUSSELL			3	3		3			2				2		4	3				2	4		2					3		4					3				2	2	3
SALINE	4		3	3	3	2	4	4	2	4	2	3	2	3	3	3		2	2	3	2		2	3		2	2	2		2					3	2		2		3	3
SCOTT	3		5	2	4					4			3	4			2			2	4				2	3	2	4	4			2								2	2
SEDGWICK				2													3			2	2		4					3												2	
SEWARD	2		5	2		2			2				2	2	4	2	2	2		2	4			4	2			3		3		2									
SHAWNEE	3		2	2	2	2	4			4	3		4		2		2		2	2	4		4	3		4		3		4		5	3		3	3				2	3
SHERIDAN			3	1	2	2			3			3	3		4					2	3							3		3				2						2	
SHERMAN	2		2						3						3					2	3				2		2	2		2					3				3		
SMITH			3	3	2	3		4	2	1		3	2		4						4					2	3	2		3					3			2	2	2	
STAFFORD			3		2				2			2		3			2			3	3						2	3		3		3		2	3	2			2		
STANTON	2		4														2			2	5											2									
STEVENS	4		4	2	3	2	2					2	3	2	4	3	2		2	3	5							3				2		1		3				2	
SUMNER			3		2					3	2		3	2	3	2	2		2	3	2		3					2	3	3					3			3		3	
THOMAS			3	3		3	3		3			3	3	2	4		3	3	2		4			3	3	4	2	4		4					4	3				2	
TREGO					3		3						4	2						2	3							3								2				2	
WABAUNSEE		2	3	2	2	2	3	3	2	4		3	2	2		4	3		3	3	4		3					2		3		4		2		2	2	2		2	
WALLACE									3						4						4							2													
WASHINGTON				2				2		4	2		2		2		2			3	2		4					2		4										2	2
WICHITA			5	2										2	5					4	5					3															
WILSON	3	2	3	2	3	2	3	2		4	3	3	3	2	3	3	2		3	3	3		4			2		4		3		3	2	3	3	2	3	2		2	2

KEY—
1—Scarce.
2—Plentiful but did no noticeable or reported damage.
3—The species was abundant. Some damage was seen or reported.
4—Local outbreaks. The species was doing severe damage in certain fields.
5—The species was in general outbreak. The insects were doing their greatest damage or were as plentiful as they ever get in a locality.

the highway department has been attempting to beautify the Kansas highway system.

Aphids were neither particularly abundant nor unusually destructive during 1941. The *pea aphid* developed to fairly large numbers in most of the alfalfa fields of the state by the middle or last of April but favorable weather for alfalfa virtually prevented injury except in the southwestern counties. Many fields in Pawnee, Stafford, Scott, Kearney, Ford, Meade, Gray and Finney Counties had areas which were severely damaged. The plants appeared as if frosted. Roy Fritz reported on April 30 that 50 per cent of the alfalfa fields around Garden City and in the Arkansas Valley showed injury by pea aphids. E. G. Kelly reported that the first cutting was severely damaged or lost in some fields but the stands revived after dragging and irrigating or following rains.

Over the rest of the state, alfalfa made a rank growth and while aphids were plentiful, no visible damage to the crop or stands occurred. Insect enemies of the aphids were abundant and the fungus disease developed in May.

Green bugs on wheat heads were observed near Wakefield and Ramona near the middle of June. No damage was seen or reported. R. H. Painter reported finding these aphids on winter barley in Cherokee County in November.

Aphids on *melons, cucumbers* and *ash trees* were about normal in 1941 while those on cabbage, radishes, and spinach were probably less plentiful than usual. Melons, however, were damaged by aphids in the upper Kaw Valley during July.

The *corn leaf aphid* was more plentiful in Riley County in July than for several years.

Spiraea aphids were more plentiful than usual in Riley County in early June and campus plants were sprayed June 18. *Arbor vitae* aphids occurred on the Kansas State College campus in small numbers at that time.

The large black *scycamore aphid* (*Longistigma caryae*) (Harris) occurred on several pin oaks on the campus the latter part of October and was sent in by several correspondents. This tree is not the usual host in this state.

Reporters mentioned aphids on the following hosts: gardens in 34 counties; flowers, 2 counties; alfalfa and peas in 17 counties; melons and cucumbers 9 counties; on wheat, oats and barley in 3 counties and on elms in 2 counties.

Cutworms of several species were definitely more numerous and more destructive than in 1940 but in general they would rank below normal, especially the pale western cutworm in the northwest.

The *army cutworm* increased in numbers. E. G. Kelly reported this species plentiful the last of March in stubble fields and pastures in Rawlins, Hodgman and Grant Counties. Many fields of wheat showed injury at the borders from this species. An outbreak covering 30 to 40 western counties developed during April. Moths were plentiful at lights and olive trees in early summer. Carl Conger reported severe damage to 50 per cent of the alfalfa fields of Pawnee County.

The *variegated cutworm* increased over 1940 and was plentiful in fields and gardens in many counties.

The *pale western cutworm* was again abundant and destructive the early part of the summer after which the species declined, probably because of ample summer and fall rains. They were reported doing damage in seven

southwestern counties and injury to strawberries was reported from Liberal in May and to wheat at Hays in April.

E. E. Russell, after making an extensive survey of infested counties by examining fields and lights at country filling stations, reported that the prospects of an outbreak next year had declined. E. G. Kelly stated that wheat had been killed by this species in many places but farmers thought the wheat plants had blown out. Approximately 100 fields were known to have been infested in Haskell County. Pale western cutworms were found mostly in trashy stubble fields with crab grass where corn or cane had been grown. None occurred in summer fallowed fields.

A dark species of unidentified cutworm attacked corn following the June rains in the Kaw Valley making replanting necessary. It followed the flooding of river bottom fields particularly. This was observed around Manhattan and Ottawa in July.

Fall army worms and *cotton cutworms* (or yellow striped army worms) were more plentiful than in 1940 in Riley, Ottawa, Anderson and surrounding counties. Late corn, alfalfa and wheat were attacked. Local outbreaks of the cotton cutworm occurred in alfalfa fields especially young stands in August requiring the use of poison bait sowings because of severe injury.

Bagworms were reported more numerous on arbor vitae in Leavenworth County and junipers from Montgomery County in July. They were reported from Bourbon County in October. It appears that in scattered localities this species was slightly more plentiful than in 1940.

Bees produced a good crop of honey in 1941, the better producers obtaining 100-150 pounds of surplus. There was little or no loss of colonies during the winter of 1940-41. They used a small amount of stores and the colonies built up rapidly on early spring bloom. There occurred a heavier growth of sweet clover along road sides and in waste places during June than in recent years. This growth produced much bloom and a fine honey flow. Many colonies swarmed one or more times.

The *beet leaf beetle* (*Monoxia puncticollia* Say) did some damage to sugar beets at Garden City during the late summer.

Beet web worms were much less plentiful on beets and Russian thistle than last year. The moths did not occur in large flights as they did in 1940.

Box elder bugs occurred during the fall of 1941 in the largest numbers since 1932. The numbers of overwintering adults in the spring appeared to be smaller than in 1940. They built up markedly during the year to annoying numbers for hibernation over the greater part of the state.

Blister beetles declined markedly in the state in numbers in 1941. Locally as in Jewell, Cheyenne, Saline, Scott, Norton, Barton, Cloud and Labette Counties noticeable injury was done to gardens and also alfalfa, potatoes, tomatoes and even young raspberry plants.

The *Southwestern corn borer* (*Diatraea grandiosella*) developed the largest outbreak and occurred in the largest number of counties ever reported for the state. The number and extent of distribution of this insect was an outstanding feature of 1941. This species was reported in the summary for 1932 and was not seen since. R. H Painter and Roy Fritz, who examined old corn stalks finding typical emergence holes in them, stated that it is highly probable that this species was present in Reno County in 1940.

This species was collected or reported in the following counties mostly from Ottawa County south and west: Edwards, Harper, Barber, Kingman, Sumner, Clark, Meade, Seward, Stevens, Morton, Grant, Haskell, Stafford, Scott, Harvey, Russell, Hamilton, Kearney, Kiowa, Saline, Reno, Finney and Gray Counties. There was no infested corn seen or reported north of Ellis County nor east of Saline County but E. G. Kelly found typically damaged corn in Douglas County near Shawnee. It is believed the larvae in this case were of the eastern species, *D. crambidoides.* R. H. Painter and Roy Fritz found infestations as high as 78 to 84 per cent in Reno County but fields which had 92 per cent stalk damage were seen in Pawnee. The yield of corn was estimated by farmers to have been reduced 10-15 per cent but 25 per cent of the stalks breaking over was common. Roy Fritz reported a reduction of 20-25 per cent in yield on the corn plots at the Garden City experiment station and 3-4 per cent damage in some fields in Gray County. In many southwestern counties, the best corn crop in about 8 years was grown this year so that injury was particularly important. Kafir and Atlas sorgo were infested in many counties, notably in Barber and Harper Counties.

The overwintering larval population in stalks was large. R. H. Painter and Roy Fritz found an average of 70.2 per cent of the larvae alive in 524 stalks and that nearly 3 per cent of the stalks had two larvae in them.

Sorghum was much less heavily infested than corn. Painter and Fritz found as high as 10.11 per cent of volunteer sorghum plants infested in corn fields but about 2 per cent only in cultivated sorghum fields.

Borers (except peach borers) in trees continued to decline in numbers and importance. Good fall rains brought excellent recovery in trees. Reporters listed borers on elms from Douglas, Rice, McPherson, Cloud, Coffey, Finney, Dickinson, and Cowley Counties; on locust in Stevens, Trego, Saline, and Douglas Counties; and on ash from Clay, Brown, and Wabaunsee Counties.

Squash vine borers were more plentiful than usual in Riley County during June. Dry weather in late June accentuated injuries to squash and pumpkin vines.

Lilac borers were reported damaging lilacs at Hillsboro.

Peach tree borers appeared to be somewhat more numerous and destructive in 1941 than 1940, judging by the number of inquiries about their control.

Canker worms again occurred in outbreak numbers in many parts of the state. The moths emerged later than usual, the fall canker worm moths beginning about February 7 at Manhattan and the moths of the spring species about March 1. By March 24, the moths were seen in considerable numbers on bands and in flight over the whole state. It was readily noticed that emergence in the cities where regular banding and spraying had been practiced was less than elsewhere. Greatest numbers of moths and greatest defoliation occurred along streams, draws and on farms. Growing conditions for trees were excellent and defoliated trees promptly put out a new crop of leaves.

Damage was particularly severe again in southeastern counties but it was less there than for the last two years. Elms in Lyons were defoliated while damage in McPherson was slight due to previous spraying programs and banding. Reports of damage were received from Edwardsville, Wichita, Fort Scott and Vermillion Valley region of southwest Kansas. Trees along creeks and in the draws were most severely attacked.

Carrot weevils (*Listronotus oregonensis*) were particularly destructive in Doniphan County in 1941 and constituted the limiting factor in carrot growing in the vicinity of Wathena. This weevil has not been taken in Riley County so far as records indicate, but specimens from Topeka are in the collection, according to H. R. Bryson.

Cattle grubs and *cattle lice* continued at approximately the same population levels as in 1941. Campaigns by the use of derris wash for both insects appeared to be giving good results. Lice were observed by E. G. Kelly to be annoying cattle in Saline, Ellsworth, Rice, Reno, Linn, Franklin, and Wilson Counties before May 1.

Chinch bugs occurred in a well defined outbreak in the eastern half of the state, or from Cloud and Reno Counties eastward but did far less damage than would have been done in a dry year. A large population emerged from winter quarters in the spring, having suffered only about 8 per cent winter mortality. They began leaving bunch grass about the middle of April but a feature of the year was the long period over which they migrated to wheat fields. They continued migrating until well into May. Favorable crop conditions resulted in an early, heavy growth of grass and wheat and the fungus disease developed early. It was a factor until July but did not control them. Many thought the bugs would not be numerous this year, but it was necessary to begin barrier construction about the first week in June in the most heavily infested counties. These were the eastern tier of counties, parts of Riley, Pottawatomie, Washington, Marshall, Nemaha and Jackson Counties and in a group of southeastern counties consisting of Chase, Greenwood, Butler, Cowley, Elk, Woodson, Wilson, Chautauqua, Montgomery and western Neosho Counties. At this time, no bugs occurred west of a line from Clay and Marion Counties. They damaged wheat stands, thinned by Hessian fly and winter killing, and in upland fields.

E. G. Kelly computed from reports by county agents that 1843 farmers built about 700 miles of barriers to protect nearly 200,000 acres of corn. About ¾ million acres of barley, sorghums and wheat were damaged during early summer and an estimated 1,000,000 acres additional were damaged by chinch bugs in the fall. The heavy growth of grass in wheat fields delayed and scattered the migration so that many had poor control from the barriers. Many bugs matured in the wheat fields and flew to corn. Wheat cutting began in southeastern counties about June 10. Eggs and red nymphs were reported by Leon Hepner in Chase County on June 23 showing late migration to wheat. Some of the adults scattered to corn and sorghum resulting in some damage by overwintering adults and first generation bugs. In such cases, barriers were of no avail. Chase, Butler, eastern Harvey and Marion Counties made most barriers but in general relatively few were necessary.

Adults flew to corn and sorghum fields in early July and the second generation was a large one but little damage was observable except to late corn, sudan, and sorghum plantings. A large population went into hibernation in the fall. The chinch bug fungus did not develop to any extent during the wet fall The year closed with chinch bugs again a threat in the eastern half of the state for 1942.

Chiggers were fully as troublesome during June, July, and August over the

state as in 1940. There were several population peaks of activity, the main one coming in early July.

Clover root curculios have increased in the region of Riley County in alfalfa fields. They occurred in about normal numbers in 1941.

Clover leaf weevils were again below normal numbers in 1941. They were scarce all season. They were reported present in Atchison, Reno, Riley, and Pottawatomie Counties.

Codling moths, in the orchard districts, prevailed at about the same population during 1941 as in previous years according to R. L. Parker. Orchards not properly cared for by spraying were damaged as usual.

Colorado potato beetles, which are generally destructive, were probably slightly more so in 1941 than in 1940. They were particularly abundant about the middle of May in Riley County and appeared to be less plentiful during the early summer. Tomato plants in cold frames were damaged in Riley County.

The *grape Colaspis* which caused concern last year by an unexpectedly large population was virtually absent in 1941.

Corn ear worms continued at the high population level of the fall of 1940 and caused considerable injury to sweet corn, and green beans in June, to field corn during the summer and to sorghum heads in the fall in many counties. R. H. Painter reported that the injury in Atchison County was higher than in Shawnee County which is the reverse of conditions observed previously. The difference was in the amount of injury to the kernels after they had hardened. Injury to corn at Manhattan was less and they were more plentiful in alfalfa fields than in 1940.

Corn bill bugs were noted by reporters from Neosho, Montgomery, Morris (at 2) and Wilson, Butler, Reno, Wabaunsee and Riley Counties (at 1). They were regarded as scarce in the state and of no economic importance.

Cotton worm moths appeared in a heavier flight than usual in the state during the autumn. Scorings of 4 were made in Cherokee, Riley, and Pottawatomie Counties; of 3 in Cowley, Trego and Saline Counties; of 2 in Wyandotte, Edwards, Clay and Washington and many others of 1.

Crickets appear to have occurred in more basements during late summer and early fall than in 1940. Black crickets were considered to have been slightly more plentiful in the state than normal.

Equine encephalomyelitis again developed into a well defined outbreak beginning in early May and continued through September. The disease, which is thought by some to be insect borne, began about two weeks earlier than usual and continued longer than usual. Dr. Ralph Graham reported 157 cases from 24 counties in the state of which 29 were fatal. Vaccination proved highly effective.

Biting flies attacking livestock again occurred in peak outbreaks following rains and were probably above normal in numbers especially in the western half of the state. Otto Wenger reported them particularly annoying in western Kansas in July. They were scored at 3 or above and described as "bad" in 60 widely scattered counties in the state. Notations indicated that biting flies were especially troublesome the last of June and in July.

Screw worm flies were present again in annoying numbers, from a first report in Gray County in May to early fall. Dehorned cattle were severely at-

tacked at Sharon Springs in June. Screw worms were severest near Kansas City and Ottawa according to E. G. Kelly. The black blow flies attacked sheep in southwestern Kansas in May particularly at the tags.

Fleas occurred in an outbreak from June to October on pets and in houses. Yards, barns, and barn lots became infested and the correspondence on the subject was heavier than for several years.

Hackberry nipple *galls* appeared to be slightly more plentiful than usual in 1941. The leaves were heavily infested and many turned yellowish in July.

Stored grain insects were both plentiful and destructive in 1941 both as a result of favorable weather and the large amount of grain in storage. Dr. R. T. Cotton of the Bureau of Entomology and Plant Quarantine, Manhattan Laboratory, summarized the situation as follows:

"Unfavorable conditions at harvest time in Kansas resulted in considerable grain being harvested with a high moisture content. This combined with a fall season which was unusually wet created conditions highly favorable for insect damage to farm stored grain. Grain inspection records for 1941 indicate that although insect infestation in wheat in Kansas was not so severe as in 1939, it closely approached conditions that existed in 1932 which with the exception of 1939 was the worst year for insect infestation in stored wheat recorded in this region for many years.

"Samples of infested grain taken from 152 bins of wheat scattered over the state and representing nearly every county showed that in order of frequency of occurrence the most abundant species were the flat grain beetle, the rice weevil, the rust red flour beetle, the sawtoothed grain beetle, the granary weevil and the cadelle. The lesser grain borer, which is not of wide spread occurrence in farm stored grain in Kansas was found in samples of wheat from bins in 4 different counties".

Grasshopper infestations in Kansas in 1941 were largely restricted to the western part of the state, with Jewell, Mitchell, Lincoln, Ellsworth, Rice and Stafford Counties forming the approximate eastern limit[3]. Toward the latter part of the season, however, important populations appeared in the extreme northeastern counties, this being apparently the result of flights. There was evidence that, in the southwestern counties, the lesser migratory grasshopper *Melanoplus mexicanus* was building up.

Hatching of *M. mexicanus* and *A. turnbulli* was first noted in western Kansas during the week ending April 26. By the week of May 17, the hatch was at its peak in southwestern Kansas, and by the first week of June, hatching was practically complete throughout the state.

During the nymphal period, injury was not generally serious, the average marginal damage in infested grain fields being estimated at 5 per cent early in June. In some cases, however, leaf injury of as much as 50 per cent had occurred in wheat. Populations in southwestern Kansas at that time varied from 5 to 200 per square yard in small-grain fields, and from 25 to 1200 per square yard at margins. During the early part of June the two-striped species, the lesser migratory, and the thistle grasshopper were all very numerous in the north-central and northwestern counties. The two latter named species were especially abundant in the southwest.

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[3]Further information on the subject may be obtained from the monthly mimeographed reports from the Grasshopper and Mormon Cricket Control Office, 820 Exchange Building, Denver, Colorado.

Appreciable numbers of adult grasshoppers, mostly *M. mexicanus,* began to appear in southwestern and central Kansas during the week ending June 7. Within a month, a majority of grasshoppers throughout the state had reached the adult age.

During the adult period, the lesser migratory grasshopper, *M. mexicanus,* was dominant in most areas as in the central counties of Smith, Osborne, Russell, Ellis, Pawnee and Barton; however, the two-striped species *M. bivittatus,* was reported to be dominant early in July. *M. differentialis* was common, but seldom dominant.

One of the most striking developments of the season was the virtual elimination of the thistle grasshopper, *Aeoloplus turnbulli bruneri,* by disease. This species had been building up for several years in western Kansas, and in 1940 was numerically the dominant species for that portion of the state. An abundant hatch occurred in 1941, but by the week ending June 14, they had begun to die in large numbers in Kearney and Finney Counties as a result of an epizootic. One week later it was reported that the species had been reduced more than 99 per cent over the entire western half of the state. Less than 12 pods of this species were found during the entire Kansas egg survey conducted in the fall. Because of the unprecedented virulence of the disease which attacked *A. turnbulli* and because of its very high degree of specificity for that grasshopper, it is suspected that it was not the common fungus disease which frequently attacks *M. bivittatus, M. differentialis* and other species, but probably the new disease reputed to have been lately found in Iowa.

Light flights were first observed in many western counties during the week ending June 21. These continued, with varying intensity, into August. Many of the flights were reported to be in a northwesterly direction. Much dispersal undoubtedly occurred in this manner. It was reported that, during the week ending June 28, flights resulted in population reductions of 25 per cent in infested grain, and 75 per cent in non-cropped areas of several southwestern counties. The participating grasshoppers appear to have come, in large part, from idle and abandoned land, and sandhill areas.

It would appear that the populations which developed in the northeastern counties were primarily the result of migration, as the egg survey of the previous fall had revealed very few pods in that area.

Injury to small grain in Kansas was not generally serious until immediately prior to and during harvest. During the third week of July it was estimated that, in the western two tiers of counties, damage to barley, by head cutting, was some 15 per cent, and that wheat and rye had each suffered some 10 per cent injury. By July 25, in northwestern Kansas, there was definite movement of grasshoppers into corn and sorghums, the former crop in some cases suffering serious damage. Corn injury was particularly noted in Phillips, Smith, Osborne, Rooks, Ellis and Russell Counties; *M. bivittatus* and *M. differentialis* were the species chiefly involved. Alfalfa in irrigated valleys suffered considerably. E. G. Kelly computed from the reports of county agents that 7,211 farmers put out 1,163 tons of dry weight of bait on 1,232,941 acres in the state in spring and summer. Approximately 1,300 more tons of bait were sown during the fall to protect wheat and young alfalfa stands.

Light hatching of second generation *M. mexicanus* was first reported on July 23, in Hamilton County. Within two weeks, nymphs were common in

northwestern counties as well, but did not occur in abundance. By August 20, however, the second generation was appearing in economic numbers in the western two tiers of counties, and by the first week of September in Stanton, Grant, and Morton Counties. By this time the second generation was entering the adult stage, and light flights occurred over Hamilton and Greely Counties on September 10.

The fall survey showed a heavy deposition in eggs in southwestern counties, to medium in most of the other counties in the western third of the state and in northeastern counties. It was estimated that the state would need 2,725 tons of poison bait to control grasshoppers in 1942 in 57 counties.

The *green striped maple* worms again were mentioned in correspondence, being reported from Greenwood County. It was recorded at 3 from Jefferson, Leavenworth, Douglas, and Shawnee Counties.

Harlequin bugs were scored at 3 in Labette, and Wyandotte Counties; at 2 in Montgomery, Neosho, Cowley, Harvey, Reno, Clay, McPherson and Marshall Counties and in many others at 1.

Hessian fly occurred in an outbreak from Cloud and Reno Counties eastward on both the crops harvested and planted in 1941. The increase in the fly and the loss occasioned caused this insect to be an outstanding entomological feature of the year. The weather during the fall of 1940 and during the whole of 1941 was highly favorable to Hession fly. The large population was fully expected.

The adult flies emerged about the first week in April in Riley County, the first eggs being found April 12. It was determined that fully 90 per cent of the wheat fields of Cherokee and Labette Counties were infested at that time. Growing conditions for wheat were excellent during the spring. Harvey and Marion, and many other counties, proved to be heavily infested also. R. H. Painter reported the latter part of May that the Hession fly infestation in wheat in the eastern third of the state was above normal. About nine-tenths of the wheat acreage east of Highway 81 was seeded before the fly-free date in the fall of 1940.

A news article published in the *Kansas City Star,* June 3, 1941 reported that Hessian fly had caused greatest loss to wheat in the state in the areas about Winfield, Parsons, Iola, Lawrence, Topeka, Pittsburg, El Dorado, Newton, Marion and Wichita. The fly augmented the loss resulting from winter killing, especially the result of the November 11, 1940 freeze, wind and floods. Many farmers in the southern tier of counties and in southeastern and other eastern counties as far north as Marshall, plowed up severely fly damaged fields and planted soy beans. Severe damage was experienced as far west as Clay and McPherson Counties. While some fields were damaged as much as 95 per cent, Leon Hepner reported in general the damage was spotted. E. G. Kelly and others estimated the wheat loss due to the fly at not less than 13,000,000 bushels in 1941 on 2,000,000 acres. W. T. Emery and E. T. Jones of the Bureau and Entomology and Plant Quarantine determined by actual counts that the average infestation in northwestern counties was 3 per cent; north-central 15 per cent; northeastern, 29 per cent, south-central, 15 per cent and southeastern, 23 per cent. The figures for most areas are lower than the actual condition because so many fields were plowed up before the counts. This sub-

stantiates the scoring reports in October that the fly was moderate to heavy (4 or 5) in northeastern and southeastern counties.

Frequent fall rains resulted in an unusually heavy growth of volunteer wheat. Further, many farmers planted early disregarding the safe date for wheat planting. Volunteer wheat in the eastern third of the state was generally infested. In many fields in southeast Kansas, it was so heavily infested that much was killed by fly. E. T. Jones found "flaxseeds" particularly abundant in early September in Jackson, Harvey and Shawnee Counties showing that a summer generation of fly had developed. Unusually heavy rains in October made wheat planting difficult. It was reported that less than 10 per cent of the wheat was seeded before November. R. H. Painter reported that the infestation in the Kansas river valley and in northeastern Kansas in early planted wheat was uniformly heavy. He found half grown larvae in wheat in southern and central counties December 1-6, explaining it by the cool, wet fall weather slowing down the life cycle rather than indicating late oviposition. Infested wheat was found by Jones at Bird City and Kelly as far west as Russell. There was evidence that considerable infestation was present in wheat in south-central Kansas planted after the safe seeding date. Reports of severe killing of stands in Sedgwick, Cowley and adjacent counties during the winter of 1941-1942 by the fly have been received.

Leafhoppers (Erythroneuras) were exceptionally plentiful in many counties in April. Great numbers of these tiny, pale overwintering leafhoppers occurred on trees, spiraeas, vines and in grass from which they were dislodged in clouds by jarring. Some tanglefoot bands were nearly covered with them. No observable damage to vegetation occurred and they were scarce in the fall.

Leafhoppers were widely reported by co-operators. They were reported from beans or peas in Smith, Linn, Harvey and Reno Counties; on grapes, shrubbery and virginia creeper in Riley, Finney, Graham, Haskell, Rice, Reno, Trego, Pottawatomie, Wyandotte, Labette and Norton Counties and on various plants in 25 other counties. Very little injury was done to apple in Doniphan, Atchison and Labette Counties though the populations were scored at 3 or 4 in each.

An unidentified species of *elm flower midge* dropped from elm trees in Mnahattan on April 12-15 in great numbers. They rolled from roofs, down spoutings and collected in piles along driveways, walks and curbs. Two or more of the tiny, pink footless larvae were obtained from many blossoms. They dropped from the bloom of European elms only. Specimens were sent to E. P. Felt. R. H. Painter reported the presence of these gall midges in about 1928.

Oak blotch mines were exceptionally plentiful during the summer of 1941. It was noted that the mines in June were as plentiful as they usually are in late summer. The larvae were nearly all parasitized, according to G. A. Dean.

Mange on hogs reached outbreak proportions in the state in 1941. More reports by scorings on these mites were received than ever before. The outbreaks covered the entire state but they were worst in the eastern quarter of the state. Scores of 3 or more were made in Doniphan, Marshall, Jackson, Atchison, Jefferson, Wyandotte, Shawnee, Wabaunsee, Cloud, Dickinson, Lyon, Osage, Coffey, Wilson, Neosho, Labette, Montgomery, Cowley, Rice,

Pawnee, Hamilton, Greeley, Sherman, Cheyenne and Norton Counties. Fully as many other counties were scored at 2. The infestation caused the greatest problem from March to June. Mange on *sheep* was reported from Cowley County.

Mosquitoes built up to more than normal numbers in September in Riley County. They were scored at 4 in Coffey, Shawnee, Doniphan and Stafford Counties. Eighteen widely scattered counties were scored at 3 and 10 at 2. All reports of large numbers came from counties along major watersheds.

Onion plant bugs in small numbers appeared on onions in Riley County the middle of May. The bugs increased and the leaf tips turned brown. It appeared that there might be severe injury to onions but timely rains overcame the effects of the feeding after the bugs scattered.

The brown banded or so called *tropical roach* continues to be sent in by correspondents. It is still less common than the German or Oriental roaches but it is evidently spreading and increasing in numbers. Leon Hepner reported it from Wilson County.

The *American dog tick* continued to be the most common tick seen or reported. Dogs at Manhattan and Kansas City were seen with these ticks attached in October.

The *spinose ear tick* was reported on cattle from Wichita in October.

Sawflies on trees and roses were more plentiful than usual in 1941. The elm or American sawfly was plentiful in southeastern counties in June again. Leon Hepner reported seeing many larvae beneath and on the trunks of elm trees in North Wichita in early June. They were so plentiful at Coffeyville that the city was reported to have bought a power sprayer for control. Two children were reported by newspapers to have gathered 15,000 adults at Parsons in April. The adults were reported as plentiful at Washington also.

The *ash saw* fly was mentioned in correspondence causing injury to ash and maple trees in eastern Kansas during early May.

Rose slugs were about normal in numbers which they caused some foliage damage by the middle of May. Favorable weather largely overcame the effects on the plants.

Grain sawflies, as the wheat stem sawfly, were of no consequence in contrast with reports of severe damage north of the state.

The *red cedar scale* is now found in all but the western fourth of the state. It continued to do considerable damage to unprotected red cedar trees, particularly those on hillsides and in pastures as far west as Ford County. Cooperators reported it from Phillips, Marshall, Harvey, Osborne, Pawnee and Riley Counties.

The *European elm* scale was again found at Goodland. It was well under control there a few years ago but since no spraying had been done for four years it became re-established. The trees were sprayed in March, 1941. The species is known to occur in Wichita also.

Scale of unknown species on apple was reported from Labette, Wilson, Johnson and Doniphan Counties; on peach in Wilson, Wyandotte, Franklin, Labette and Neosho Counties; on buffalo grass in Cherokee, on rose bushes in Brown; Virginia creeper in Thomas and locust in Stevens Counties.

The red bud *leaf roller* (*Gelechia cercerisella*) developed to destructive numbers requiring spraying in Riley County in July.

Red Spider mite injury to vegetation though wide spread was not severe during 1941, the damage being less than in 1940 and below normal in general. These mites developed on flowers and garden plants the latter part of June.

Red spider damage to cedars and evergreens was scored at 1 to 3 from Shawnee, Wyandotte, Allen, Rice, Ellis, McPherson, Osborne, Stafford, Rawlins and Marshall Counties; on elm in Trego, Stevens and Riley and shrubs and vine plants in Haskell, Riley, Dickinson and Doniphan Counties.

Squash bugs were less plentiful and less destructive in 1941 than in 1940. They emerged from winter quarters in fully normal numbers and began to be destructive to squash and pumpkin vines during June. They did not build up, however, and a relatively small number went into hibernation.

The *strawberry leafroller* was a major threat to strawberry plants in Riley and several northeastern counties during May. The population around Manhattan was larger than usual and some fall injury was reported. In Doniphan County, only one picking was made from many fields whereas those who controlled this pest made 4 to 6 pickings.

The *strawberry root worm* was discovered by P. G. Lamerson in Doniphan County during the late summer doing considerable damage to strawberry fields.

The *sweet potato weevil* (*Cylas formicarius*) was discovered for the first time in Kansas near Hutchinson in September. No live specimens were found by E. G. Kelly and R. L. Parker on October 29, and their presence was undoubtedly due to a grower purchasing infested tubers shipped from a southern state.

Striped cucumber beetles continued slightly below normal in early summer but developed to destructive numbers at Manhattan the latter part of July and killed most of the vines. A fair crop of cucumbers, however, was harvested locally where the plants were kept dusted.

The *12 spotted cucumber beetle* was more plentiful in Riley County than in the previous year. In addition to cucumbers, they damaged newly planted tomatoes and beans. They were abnormally plentiful in alfalfa fields and in melon and pumpkin blossoms all season.

Termites were normal in numbers judging by observations and the usual heavy correspondence. They swarmed at Manhattan March 24, May 3, October 6, and October 23.

Tomato hornworms were reported to have been less numerous than usual in 1941. D A. Wilbur reported the species at a low ebb in Riley County.

White grubs in general were probably below normal in destruction and population in 1941. However, wheat white grub adults were observed in considerable numbers by Leon Hepner emerging in wheat fields in Morris County in early June. The beetles gathered on weeds in noticeable numbers. No damage to wheat was observed. H. R. Bryson observed them emerging from sod in Riley County and clustering on the lead plant (*Amorpha canescens*) from June 6 to July 18. Many of these weeds were defoliated. He considered this species to have been more plentiful in Riley County than ever before recorded. The year marked the apex of a gradual increase from the drouth period of 1934. This species was noted by observers in Marshall and Crawford Counties also.

White grubs in lawns were fairly common but favorable rains in June and

October left lawns throughout the state in the best condition for many years.

The *wheat stem maggot* was wide spread in the state in somewhat larger numbers than in 1940. In Trego and Scott Counties, M. C. West reported 5-10 per cent of the wheat heads blasted up to mid-June.

Wireworm adults were reported by Leon Hepner unusually plentiful hiding among the leaves of corn and sorghum plants in July throughout much of the eastern half of the state. The presence of three to five in each plant was common.

False wireworms were less numerous and did less damage than for many years during the fall of 1941. They were present at seeding time in western counties but ample rains brought prompt germination in nearly all counties. While only the early sown wheat was really exposed to these larvae, the remarkably heavy volunteer wheat stands indicate that little or no commercial loss was experienced in the early sowings.

False wire worms were scored at 3 in Grant, at 2 in Thomas, Logan, Ellis, Rice, Finney, and Stevens, and at 1 in 14 others as far east as Saline County.

SUMMARY AND CONCLUSIONS

The year 1941 was the second wettest in Kansas since records have been kept and averaged slightly warmer than normal. It was a good crop year in spite of the heaviest flood loss in the history of the state and the difficulties of harvesting and planting grain in wet months. The spring was cool and about two weeks late while June and October were abnormally wet, cool and cloudy.

The year 1941 was characterized by a large, destructive outbreak of the hessian fly, by a moderately large outbreak of chinch bugs in the eastern half of the state, by the largest and most extensive population of the southwestern cornborer in the history of the state and the moderately heavy grasshopper outbreak in the western third of the state. Other insects and mites occurring in very large or *outbreak* numbers were: box elder bugs; spring and fall cankerworms; codling moth; strawberry leafroller; strawberry root worm; carrot weevil; biting flies on livestock; fleas on pets and in houses; stored grain insects and hog mange. The following insects, ticks and mites, in addition to the above species, were *more numerous in 1941 than in 1940* in Kansas: European elm scale; spirea, black sycamore, corn leaf and pea aphids; army, variegated cotton, and black cut worms; evergreen bag worms; squash vine borer; potato beetles; cotton moths; corn bill bugs; American dog tick; clover root curculios; oak blotch miners; green striped maple worms; grape and potato leaf hoppers; elm flower midge; mosquitoes; American and ash saw flies.

The following insects were judged to be approximately *as plentiful in 1941 as in 1940*: the red cedar scale; aphids on ash, cucumbers and melons; fall army worm; cattle grubs; cattle lice, especially sucking; corn ear worms; screw worms; tomato hornworms; red bud leafroller, rose slugs; striped and spotted cucumber beetles.

The following insects and mites were *less plentiful* than in 1940: house and lawn species of ants; green bug; pale western cutworm; codling moth; blister beetles; flat headed tree borers; chiggers; crickets in basements;

clover leaf weevils; grasshoppers, except in western counties; onion plant bugs; red spiders; squash bugs; termites; white grubs in lawns; wheat white grub; and false wireworms.

Species which were *scarce or nearly absent* includes only the beet and alfalfa web worms, brown mites on wheat and the wheat stem maggot.

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Fragmentary Crinoids From the Lower Permian of the Manhattan Area

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INTRODUCTION

Numerous Lower Permian horizons outcropping in the vicinity of Manhattan, Kansas, have yielded an abundance of fragmental crinoidal remains. Fairly complete crinoid crowns, to be described in a later paper, also have been obtained from three of the horizons. Fragmentary remains, however, are much more common local fossils and, because of their relative abundance and frequent occurrence, are potentially important in stratigraphic paleontology.

The purpose of the present investigation is to determine what fragmentary crinoidal remains occur in stratigraphic horizons exposed in the Manhattan area and to determine the stratigraphic significance these forms may have. The specimens utilized as the basis of the study were collected and catalogued by the authors and by numerous students enrolled in field courses offered by the Department of Geology.

LOCALITY INDEX

The specimens described on subsequent pages were collected from the following horizons, these cropping out at the localities designated:

Foraker formation
  Americus limestone member
    Location A—N.W. ¼, N.E. ¼, sec. 4, T. 10 S., R 8 E. (Pottawatomie County)
  Hughes Creek shale member
    Location B—N.E. ¼, S.E. ¼, sec. 7, T. 10 S., R. 8 E. (Riley County)
    Location C—S.W.¼, sec 24, T. 10 S., R. 7 E. (Riley County)
    Location D—N.W. ¼, N.E. ¼, sec. 24, T. 10 S., R. 7 E. (Riley County)
    Location E—N.E.¼, N.W. ¼, sec. 5, T. 11 S., R. 9 E. (Riley County)
Red Eagle formation
  Bennett shale member
    Location F—N.W. ¼, N.E. ¼, sec. 24, T. 10 S., R. 7 E. (Riley County)
Beattie formation
  Florena shale member
    Location G—S E. ¼, N.W. ¼, sec. 7, T. 10 S., R. 8 E. (Riley County)
    Location H—N.E. ¼, N.W. ¼, sec. 26, T. 10 S., R. 7 E. (Riley County)
Bigelow formation
  Blue Rapids shale member
    Location I—S.W. ¼, S.E. ¼, sec. 1, T. 11 S., R 6 E. (Riley County)
Wreford formation
  Threemile limestone member
    Location J—S.W. ¼, N.W. ¼, sec. 33, T. 10 S., R. 8 E. (Riley County)
    Location K—Threemile Quarry, Fort Riley Military Reservation
  Havensville shale member
    Location L—S.E. ¼, N.E. ¼ sec. 7, T. 11 S., R. 8 E. (Riley County)

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Barneston formation
Oketo shale member
Location M—N.W. ¼, N.E. ¼, sec. 1, T. 9 S., R. 4 E. (Riley County)
Location N—S.E. ¼, N.W. ¼, sec. 24, T. 9 S., R. 6 E. (Riley County)
Location O—N.E. ¼, N.W. ¼, sec. 8, T. 12 S., R. 6 E. (Geary County)
Fort Riley limestone member
Location P—N.E. ¼, N.W. ¼, sec. 28, T. 9 S., R. 6 E. (Riley County)
Winfield formation
Grant shale member
Location Q—N.W. ¼, N.E. ¼, sec. 1, T. 9 S., R. 4 E. (Riley County)

SYSTEMATIC DESCRIPTIONS

Disarticulated crinoidal structures, less accurately referred to as "fragmentary crinoids", were first assigned names in accordance with the plan suggested by R. C. Moore in 1938 (Denison Univ. Bull., vol. 33, pp. 165-250, pls. I-IV, figs. 1-14). In a recent conference, Dr. Moore indicated that he prefers to modify this plan by substituting structural names, as columnals, etc., for the Latin group names proposed in 1938. This recommendation will be followed as will also his further recommendation that the names of "species"-rank, or their equivalents, be retained.

COLUMNALS

Included here are those skeletal structures which constitute the stem of the crinoid. Columnals occur in the local horizons as single, disassociated checker-like discs or as a number of such discs fortuitously preserved associated. In no specimen collected locally did the portion of the stem so preserved equal more than a small fraction of the original length of the stem. Columnals were designated as "Crinostyli", a group of divisional rank, in the 1938 classification of Moore.

Columnal *minima* Byrne and Seeberger, new form
Plate I, figures 1, 2

Description:

Circular, with relatively large circular lumen tending to become pentagonal. Crenellae well-defined but short, numbering approximately thirty-eight. Surface of articular face between lumen and crenellae smooth. Periphery smooth.

Measurements of Columnal *minima* show the following ranges: width of articular face, 4.25 to 7.50 mm.; width of lumen, 1.00 to 2.50 mm.; length of short internodal, 0.75 to 1.50 mm.; length of intermediate internodal, 1.00 to 2.00 mm.; length of nodal, 1.75 to 4.00 mm.

Occurrence:

The known range of this type of columnal is from the Hughes Creek shale member of the Foraker formation to the Grant shale member of the Winfield formation.

Discussion:

Two forms of ossicles may be distinguished, nodals and internodals. There are three internodals between successive nodals, the mid-internodal intermediate in size between the nodals and the smaller internodals.

Columnal *intermedia* Byrne and Seeberger, new form
Plate I, figures 3, 4

Description:

Circular, with relatively large circular lumen tending to become pentagonal.

Crenellae well-defined but short, numbering approximately eighty. Surface of articular face between lumen and crenellae smooth. Periphery smooth.

Only the nodal form of ossicle has been found.

Measurements of Columnal *intermedia* show the following ranges: width of articular face, 12.00 to 12.75 mm.; width of lumen, 3.00 to 4.50 mm.; length of nodals, 1.50 to 2.00 mm.

Occurrence:

The known range is from the Americus limestone member of the Foraker formation to the Grant shale member of the Winfield formation.

Discussion:

This form is distinguished from one of the *minima* type by its greater number of crenellae, by its greater width of the articular face, and by the apparent absence of the internodal form.

Columnal *maxima* Byrne and Seeberger, new form
Plate I, figures 5, 6

Description:

Circular, with relatively large circular lumen tending to become pentagonal. Crenellae well-defined, extending inward to the edges of the lumen, numbering approximately eighty-four to ninety. Surface of articular face between lumen and crenellae smooth. Periphery smooth.

Only the nodal form of ossicle has been found.

Measurements of C. *maxima* show the following ranges: width of articular face, 8.00 to 12.00 mm.; width of lumen, 1.75 to 3.00 mm.; length of nodals, 1.00 to 2.00 mm.

Occurrence:

The known range of this form is from the Hughes Creek shale member of the Foraker formation to the Florena shale member of the Beattie formation.

Discussion:

This form may be distinguished from C. *minima* and C. *intermedia* by the crenellae, which extend to the edge of the lumen in C. *maxima* alone.

Facetals

The structures here termed "facetals" are the equivalents of the ossicles collected together in Moore's "Division Crinarthra". Facetals are those crinoid calyx plates which bear only a single surface for the articulation of the free arm. In contrast are the somewhat similar plates termed "pinnates", later to be described, which bear two or more articular facets.

Facetal *circularia* Byrne and Seeberger, new form
Plate I, figure 11

Description:

Pentameral; marginal angles rounded, obscuring the three angles on the lower margin of the plate. Facet equal in width to the greatest width of the plate. Outer ligament area poorly developed, without a depression, lacking well-developed ridges. Inner face of the plate elevated. Suture faces not distinct. The outer surface is smooth and unornamented.

Measurements of specimens of this type show the following ranges: width of plates, 15.00 to 16.00 mm.; height of plates, 8.00 to 9.00 mm.; length of facet, 4.00 to 5.00 mm.

Occurrence:

Grant shale member of the Winfield formation.

Facetal *triangulata* Byrne and Seeberger, new form
Plate I, figures 7, 8, 9

Description:

Pentameral; articular facet possessing a transverse ridge. Facet equal in width to the greatest width of the plate. Transverse ridge is moderately elevated; outer ligament area short and slightly depressed; inner ligament area concave or nearly flat, lateral furrows and oblique ridges generally present. Lateral sutures triangular, inner suture face depressed. Inner face of the plate is smooth and concave. The outer surface is smooth and unornamented.

Measurements of plates of F. *triangulata* show the following ranges: width of plates, 12.00 to 19.00 mm.; height of plates, 6.50 to 11.00 mm.; length of facet, 5.00 to 7.00 mm.

Occurrence:

The known range is from the Hughes Creek shale member of the Foraker formation to the Grant shale member of the Winfield formation.

Discussion:

This form may be distinguished from F. *circularia* by the triangular outline of the later sutures and by the distinctness of the suture faces.

Facetal *tuberculata* Byrne and Seeberger, new form
Plate I, figure 10

Description:

Pentameral; articular facet possessing a transverse ridge; facet equal in width to the greatest width of the plate. Transverse ridge is moderately elevated; outer ligament area short and slightly depressed; inner ligament area concave or nearly flat, lateral furrows and oblique ridges generally present. Inner face of the plate is smooth. Suture faces are distinct.

Outer surface of the plate is characterized by a distinct pattern of tubercules.

Measurements of the figured specimen are: width of plate, 11.00 mm.; height of plate, 6.00 mm.; length of facet, 4.00 mm.

Occurrence:

Hughes Creek shale member of the Foraker formation.

Discussion:

This form may be distinguished from F. *triangulata* by the presence of tubercules on the external surface.

POLYGONALS

Ossicles known as "polygonals" were classed by Moore (1938) in the "Division Crinopolygona". The structures included under this term are characterized by the absence of features which would identify them with any other structural group.

Polygonal *pentagona* Byrne and Seeberger, new form
Plate I, figures 12, 13

Description:

Pentagonal plates symmetrical in outline; strongly incurved at the base; smooth, unornamented exterior.

Measurements are as follows: width of plate, 12.00 mm.; height of plate, 9.00 mm.; thickness, 2.50 mm.

Occurrence:

The known range is from the Hughes Creek shale member of the Foraker formation to the Grant shale member of the Winfield formation.

Polygonal *hexagona* Byrne and Seeberger, new form
Plate I, figures 16, 17

Description:

Hexagonal plates symmetrical in outline, with the upper side of the plate truncated; strongly incurved at the base; smooth, unornamented exterior.

Measurements are as follows: width of plate, 11.00 mm.; height of plate, 10.00 mm.; thickness, 2.00 mm.

Occurrence:

The known range is from the Florena shale member of the Beattie formation to the Grant shale member of the Winfield formation.

Discussion:

Basals as a rule are pentagonal in outline. The posterior basal in some specimens has an hexagonal instead of a pentagonal outline, the upper side being truncated for support of the interradial. The above described groups may be merely plates of a single genus.

PINNATES

As mentioned previously, the ossicles designated as "pinnates" may resemble facetals but may be distinguished by the presence of two or more articular facets. The pinnates were included by Moore in the "Division Crinoptera".

CONCLUSIONS

The stratigraphic distribution of the forms previously described is here summarized. Table I presents the same information in tabular form.

Columnals of the *minima* type are abundantly represented throughout the section examined, having been found in the Hughes Creek shale, the Bennett shale, the Florena shale, the Threemile limestone, the Oketo shale, the Fort Riley limestone and the Grant shale.

Columnal *intermedia* is represented throughout the section, occurring in the Americus limestone, the Bennett shale, the Threemile limestone and the Grant shale. However, the type is outnumbered by C. *minima* in the horizon in which they both occur.

The exact ranges of C. *minima* and C. *intermedia* are not known, the examination having been confined to the local section. No published record of these forms in horizons older or younger than those discussed has been found. Further study might delimit the stratigraphic ranges more exactly, in which case, because of their abundance, isolated columnals might prove of correlative value.

C. *maxima* appears to be limited to the lower half of the examined section, appearing in the Hughes Creek shale and the Florena shale, in both of which it occurs sparingly. It is probable that C. *maxima* does not occur in horizons above the Florena shale. This form, then, may be established, tentatively, as an index of horizons below the Morrill limestone Its lower limit has not yet been determined.

EXPLANATION OF PLATE I

(all figures x2)

Fig.

1. Columnal *minima,* lateral aspect showing nodal and internodal form of ossicles; Bennett shale, Location F.
2. Columnal *minima,* view of articular face showing short crenellae and pentagonal lumen; Bennett shale, Location F.
3. Columnal *intermedia,* view of articular face showing short, strong crenellae, large, pentagonal lumen; Bennett shale, Location F.
4. Columnal *intermedia,* lateral aspect showing nodal form of ossicle; Bennett shale, Location F.
5. Columnal *maxima,* view of articular face showing long, fine crenellae; Florena shale, Location G.
6. Columnal *maxima,* lateral aspect showing nodal form of ossicle; Florena shale, Location G.
7. Facetal *triangulata,* front view showing pentameral outline; Havensville shale, Location L.
8. Facetal *triangulata,* side view showing triangular form of the lateral cuture; Havensville shale, Location L.
9. Facetal *triangulata,* view of articular facet; Havensville shale, Location L.
10. Facetal *tuberculata,* front view showing the pattern of tubercules; Hughes Creek shale, Location C.
11. Facetal *circularia,* front view showing rounded margin; Grant shale, Location Q.
12. Polygonal *pentagona,* front view showing pentagonal outline; Hughes Creek shale, Location C.
13. Polygonal *pentagona,* view of inner side of plate; Hughes Creek shale, Location C.
14. Delocrinus sp., pinnate, front view; Florena shale, Location G.
15. Delocrinus sp., pinnate, top view showing articular facet; Grant shale, Location Q.
16. Polygonal *hexagona,* front view showing hexagonal outline; Havensville shale, Location L.
17. Polygonal *hexagona,* view of inner side of plate; Havensville shale, Location L.

TABLE I. Stratigraphic occurrences of lower Permian Fragmentary Crinoids

		Columnals			Facetals			Polygonals		Pinnates
Stratigraphic Horizons	Locality Numbe	C. minima....	C. intermedia	C. maxima....	F. triangulata	F. tuberculata	F. circularia..	P. pentagor	P. hexagon.	Delocrinus
Grant Shale	Q	x	x		x		x		x	x
Fort Riley limestone	P	x								
Oketo shale	O	x			x			x		
	N	x								
	M	x								
Havensville shale	L				x			x	x	
Threemile limestone	K	x			x					x
	J		x							
Blue Rapids shale	I							x		
Florena shale	H	x		x	x					
	G	x		x	x			x	x	x
Bennett shale	F	x	x							
Hughes Creek shale	E			x						
	D	x		x						
	C	x		x	x	x		x		
	B	x		x	x			x		
Americus limestone	A		x							

Facetal *triangulata* ranges abundantly throughout the examined section, occurring in the Hughes Creek shale, the Florena shale, the Threemile limestone, the Havensville shale, the Fort Riley limestone, and the Grant shale. F. *tuberculata* is confined to a single horizon, the Hughes Creek shale, a single specimen having been found. F. *circularia* thus far has been found in a single horizon alone, the Grant shale.

Polygonal *pentagona* is represented abundantly in the Hughes Creek shale, the Florena shale, the Threemile limestone, and the Grant shale. P. *hexagona* is restricted to the upper part of the section, appearing first in the Florena shale. The Havensville shale and the Grant shale also have yielded a limited number of specimens of this type.

Isolated radial and basal plates, on the basis of this study, appear to have little or no value as stratigraphic indices insofar as the local section is concerned, since the one common form ranges throughout the full thickness of it and the other forms are too uncommon fossils. In view of the case with which the radials may be distinguished, further investigation through a greater stratigraphic range might demonstrate the correlative utility of the group.

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A Study of the Oligocene Leporidae in the Kansas University Museum of Vertebrate Paleontology[1]

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INTRODUCTION

The following is a report on the Oligocene Leporidae in the Kansas University Museum of Vertebrate Paleontology.[2]

Over 500 specimens of North American Oligocene Leporidae were examined including the comparative study of about 300 specimens of the American Museum collection. Of the latter, only lower dentitions were stud:ed as time was limited.

PALAEOLAGUS LEIDY, 1856

1856. *Palaeolagus* Leidy. Notices of remains of extinct Mammalia, discovered by Dr. V. F. Hayden in Nebraska Territory. Proc. Ac. Nat. Sci. Phila., vol. 8, pp. 89-90.

1873. *Tricium* Cope. Third notice of extinct Vertebrata from the Tertiary of the Plains. Palaeo. Bull. No. 16, pp. 1-8.

1931. *Protolagus* Walker. Notes on North American fossil lagomorphs. The Aerend, vol. II, No. 4, pp. 227-240, 1 pl.

Generic diagnosis.—P_3 possesses an external reëntrant angle which is evident throughout the greater part of the duration of life, and two internal reëntrant angles, the posterior angle being lost early in life and the anterior angle disappearing after "middle age". P_4-M_2 have two columns which become joined on the lingual side late in life. P^3 has an external reëntrant angle which is well developed in early life and is maintained either as an external reëntrant angle or a crescent until with age, it disappears because of wear. P^3-M^2 all have internal reëntrant angles which are retained through old age.

·*PALAEOLAGUS HAYDENI* LEIDY, 1856

1856. *Palaeolagus haydeni* Leidy. Notices of remains of extinct Mammalia, discovered by Dr. V. F. Hayden in Nebraska Territory. Proc. Ac. Nat. Sci. Phila., vol. 8, pp. 89-90.

1873. *Palaeolagus agapetillus* Cope. Second notice of extinct Vertebrata from the Tertiary of the Plains. Palaeo. Bull. no. 15, pp. 1-6.

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[1]A condensation of a thesis submitted to the Department of Zoology and the Faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

[2]It is through the courtesy of Dr. H. H. Lane, Director of the Museum of Natural History that I have been given permission to study the Kansas University Museum of Vertebrate Paleontology collection. I wish to express my appreciation to Dr. Claude W. Hibbard, under whose direction this study was undertaken, for his continued interest and for various suggestions and criticisms. To the late Dr. Walter Granger I am especially indebted for permission to study the North American Oligocene Leporidae in the American Museum of Natural History and for providing facilities for me while there during the summer of 1941. I am also indebted to Mr. George F. Sternberg of the Fort Hays State College, Kansas, for the loan of the type and paratype of *Protolagus affinus* Walker. The drawings were made by Miss Frances Watson.

Transactions Kansas Academy of Science, Vol. 45, 1942.

1873. *Tricium annae* Cope. Synopsis of new Vertebrata from the Tertiary of Colorado, obtained during the summer of 1873, pp. 1-19. Washington Govt. Printing Office, Oct. 1873.
1873. *Tricium avunculus* Cope. Third notice of extinct Vertebrata from the Tertiary of the Plains. Palaeo. Bull. no. 16, pp. 1-8.
1873. *Tricium leporinum* Cope. Third notice of the extinct Vertebrata from the Tert:ary of the Plains. Palaeo. Bull. no. 16, pp. 1-8.
1921. *Palaeolagus haydeni agapetillus* Cope, Troxell. *Palaeolagus,* an extinct hare. Amer. Journ. Sci., series 5, I, 22, pp. 340-348, 29 figs.
1931. *Protolagus affinus* Walker. Notes on North American fossil lagomorphs. The Aerend, vol. II, no. 4, pp. 227-240, 1 pl.
1931. *Archaeolagus striatus* Walker. Notes on North American fossil lagomorphs. The Aerend, vol. II, no. 4, pp. 227-240, 1 pl.

Type locality.—"At the head of Bear Creek, a tributary of the Cheyenne River, Dakota" (Leidy, 1871). This would place it in Armstrong County, South Dakota.

Horizon.—Middle Oligocene, probably from the Oreodon beds.

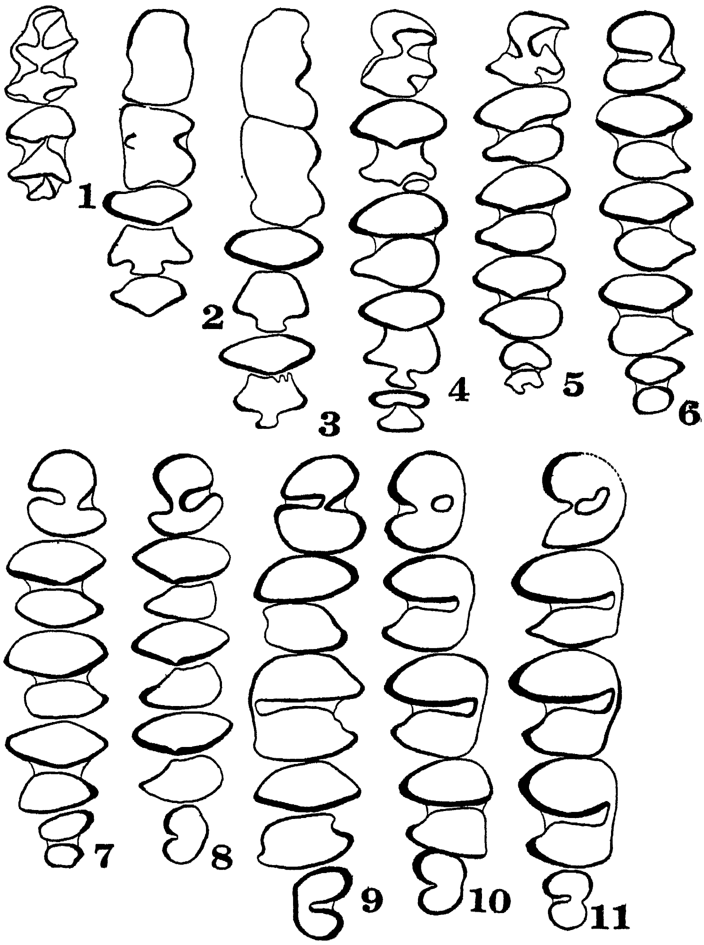
Specific characters.—More hypsodont than *Palaeolagus temnodon* Douglass. P_3 lacks an anterior reëntrant angle in immature stage. The internal reëntrant angles of the upper molars persist for a longer period of life than in *P. temnodon,* but are not as persistent as in *Palaeolagus burkei* Wood. *P. haydeni* can further be distinguished from *P. temnodon* by the presence of crenulations on the posterior border of the internal reëntrant angles of the upper molars in young specimens. However, these crenulations cannot be seen in older specimens. Old *P. haydeni* can be distinguished from old *P. burkei* by the persistence of crescents in the upper molars of the former. If the crescents of *P. haydeni* have disappeared because of wear, the internal reëntrant angles at this stage are seen as enamel lakes, a condition never seen in *P. burkei. P. haydeni* is larger than either *P. temnodon* or *P. burkei.*

Since in neither Troxell's (1921) nor Dice and Dice's (1935) work were the lower dentitions associated with the upper dentitions, no positive correlation can be made between the uppers and the lowers as to age and wear. The present study is at fault in this respect, as only two associated upper and lower dentitions were studied, one being the type of *Protolagus affinus* Walker. There is no doubt a large number of complete associated upper and lower dentitions in museums or private collections which should be brought together and a study made of them. Since the writer has not had ample opportunity to do so, he is following the example of previous workers in studying the upper and lower dentitions as separate entities. The specimens described below are presented in order of age of wear of the dental patterns. Each jaw is described separately and the changes noted.

DESCRIPTION OF SPECIMENS

Lower Dentitions

A fragmentary ramus bearing dP_3 and dP_4, KUMVP No. 6131 (Fig. 1); locality, northeastern Colorado. This is the most immature specimen in the collection. The ramus is extremely small and both teeth are barely worn. DP_3 has three columns, the anterior column broadly connected with the medium column and the latter connected to the posterior column by a narrow



EXPLANATION OF PLATE I

Fig.	KUMVP no.	
1	6131	occlusal view of left dP_3 and dP_4.
2	67	occlusal view of right dP_3, dP_4, M_1 and the anterior column of M_2.
3	6012	occlusal view of right dP_3, dP_4, M_1 and M_2.
4	6136	occlusal view of left P_3-M_3.
5	70	occlusal view of left P_3-M_3.
6	5986	occlusal view of right P_3-M_3.
7	59	occlusal view of right P_3-M_3.
8	2879	occlusal view of left P_3-M_3.
9	6140	occlusal view of right P_3-M_3.
10	6138	occlusal view of left P_3-M_3.
11	104	occlusal view of left P_3-M_3.

All figures, X 6.

neck of enamel. DP_4 also has three columns. The anterior column is broader than that of dP_3 and is not connected with the median column by enamel. The latter is not connected with the posterior column by enamel, the posterior column being one third the size of the posterior column of dP_3. Anteroposterior length of dP_3-dP_4; 4.2 mm.

A right ramus bearing dP_3-M_3, KUMVP No. 67 (Fig. 2); locality, Dead Man's Canyon, northeastern Colorado. DP_3 is well worn, and all the columns appear to have joined to form an almost featureless tooth, not quite flat and without any reëntrant angles. However, the tooth is slightly damaged and the lack of reëntrant angles is probably due to that fact. The tooth is low crowned, which is a further indication of its youth. DP_4 is two columned, a short external reëntrant angle dividing the two. M_1 is double columned, the posterior column with an additional lobe. M_2 is not much worn, and the third column is not joined to the second column. M_3 barely shows, but can be seen to be erupting as a two columned tooth. Anteroposterior length of dP_3-M_3; 8.6 mm.

A right ramus bearing dP_3-M_2, KUMVP No. 6012 (Fig. 3); locality, Yuma County, Colorado. This specimen is much larger than specimen No. 67, and its dental pattern is slightly older. DP_3 has two small external reëntrant angles and still shows signs of having had three columns. The tooth is two rooted and ready to be shed. P_3 can be seen coming in underneath. DP_4 is worn almost flat and is ready to be shed. P_4 can be seen coming in underneath. M_1 has two columns, the posterior column having an additional posterior lobe. M_2 is also two columned with the posterior column having the third lobe. Anteroposterior length of dP_3-M_1; 6.6 mm.

A left ramus bearing P_3-M_3, KUMVP No. 6136 (Fig. 4); locality, northeastern Colorado. P_3 has just erupted and is barely worn. Portions of the roots of dP_3 are still visible. P_3 is two columned. The anterior column is broadly conical with enamel across the top and down the posterior face of the column. The posterior column is much lower than the anterior column, and also has a greater transverse diameter. There is a single external reëntrant angle and two internal reëntrant angles. P_4 is made up of two columns only slightly worn. The posterior lobe of P_4 (third lobe) is separated from the posterior column by cement. M_2 is two columned and still possesses the secondary lobe of the posterior column. M_3 is barely worn and consists of two columns, the posterior column being much lower than the anterior column. Anteroposterior length of P_3-M_3; 9.2 mm.

A right ramus bearing P_3-M_3, KUMVP No. 4936 (Fig. 25); locality, Cedar Creek, northeastern Colorado. P_3 possesses an external reëntrant angle. There are two internal reëntrant angles. The enamel on the anterior border of P_3 is beginning to show rather thinly in the form of an antero-lingual reëntrant angle. P_4 is double columned, the posterior column possessing the third lobe. M_1 is double columned. M_2 is double columned and the third lobe is not as distinct as in preceding specimens, but still present. M_3 is double columned, the anterior column slightly higher than the posterior column. Because of the presence of the antero-lingual reëntrant angle on P_3, this specimen is provisionally placed with *haydeni*. It might be said that this condition was due to the manner in which the tooth was worn down, but additional specimens discussed later on in this paper still possess this reëntrant

angle. It is the first of the reëntrant angles of P_3 to disappear because of wear. Evidence of this is the fact that the groove down the anterior face of the tooth is not very deep, though it is definite. Anteroposterior length of P_3-M_3; 8.1 mm.

A left ramus bearing P_3-M_3, KUMVP No 70 (Fig. 5); locality, Cedar Creek, northeastern Colorado. The dental pattern of this specimen is almost identical with that of the type of *Protolagus affinus* Walker. P_3 has a single external reëntrant angle and two internal reentrant angles. P_4-M_2 are all double columned and no trace of the third lobe is present. M_3 is double columned, both columns at this stage being the same height. The posterior column of M_3 possesses a posterior reëntrant angle, which is just being cut off from the outside. According to Dice and Dice (1935) this is the proper pattern of M_3 with P_3 at this stage. Anteroposterior length of P_3-M_3; 8.2 mm.

A right ramus bearing P_3-M_3, KUMVP No. 265 (Fig. 26); locality, Hat Creek Basin, northwest Nebraska. P_3 possesses an external reëntrant angle. The anterior internal reëntrant angle is well developed, but the posterior internal reëntrant angle is thin and almost cut off from the outside. The anterior reëntrant angle extends about one third of the way across the crown of the anterior column of the tooth. P_4, M_1 and M_2 are all double columned with M_2 showing a slight trace of the third lobe. The length of time that the third lobe is present seems to be a matter of individual variation, since it is absent in No. 70, a younger specimen. M_3 possesses an internal and external reëntrant angle, is double columned and the enamel is uniform. There seems to be a slight indication of a third lobe. Both columns are connected by a thin neck of enamel. Dice and Dice (1935) state that exceptional specimens possess the third lobe on M_3. This, though possible, seems to me to be incongruent with an M_3 possessing a posterior reëntrant angle. This specimen possessing a young P_3 with a comparatively old M_3, that is, P_3 possesses both internal reëntrant angles and M_3 has both of its columns connected by enamel, differs entirely from specimen No. 70 which also has a young P_3, but also has a young M_3, that is, double columned and with a posterior reëntrant angle. Both of these specimens differ markedly from U.S.N.M. No. 13562 figured by Dice and Dice (1935) which shows an older P_3, that is, the posterior internal reëntrant angle has been cut off and is seen as a thin lake of enamel, with a young P_4, M_2 and M_3, that is, P_4 and M_2 possess the third lobe and M_3 possesses a posterior reëntrant angle. This was considered by Dice and Dice to be individual variation, but I am of the opinion that the variation spreads over too wide a field. I believe that there is a possibility that two or more separate but similar species very much alike in the later stages of life may be confused and that only a large number of associated dentitions can decide this point with assurance. Anteroposterior length of P_3-M_3; 9 6 mm.

A left ramus bearing P_3-M_3, KUMVP No. 267 (Fig. 27); locality, Hat Creek Basin, northwest Nebraska; horizon, probably Middle Brule. The posterior internal reëntrant angle of P_3 is thin but not yet cut off. There is a short but definite antero-lingual reëntrant angle. P_4, M_1 and M_2 are all double columned with the third lobe persisting in M_2. The internal reëntrant angle of M_3 has been lost because of wear, the posterior and anterior columns being connected on the lingual side by a wide band of dentine. The presence of the anterior reëntrant angle of P_3 may or may not be significant, but it

raises possibilities. It may be conjectured that the anterior reëntrant angles of the KUMVP specimens may be atavistic in character since it is a definite occurrence in the lower Oligocene *Palaeolagus temnodon* Douglass. It is possible that these specimens represent a heretofore undescribed species more closely related to *P. temnodon* than to *P. haydeni*. Anteroposterior length of P_3-M_3; 9.9 mm.

A right ramus bearing P_3-M_3, KUMVP No. 5986 (Fig. 6); locality, Cedar Canyon, northeastern Colorado. P_3 has lost the posterior internal reëntrant angle giving the tooth the typical "hour-glass" form of the Palaeolaginae. P_4, M_1 and M_2 are all double columned and no traces of the third lobe are present. M_3 is double columned and these are not connected, nor is there any sign of their becoming connected soon since there is quite a bit of cement betwen the two and the columns are open to the alveolus. Here again, there is a discrepancy in the wear patterns of P_3 and M_3. In specimens 265 and 267, we find a young P_3 with an old M_3. This is entirely different from the condition in the specimen under discussion, since the latter has an old P_3, or at least a P_3 without the posterior internal reentrant angle and a young M_3. I am of the opinion that there should be some correlation between the patterns of wear of P_3 and M_3 which should be looked for in future work. Anteroposterior length of P_3-M_3; 8.9 mm.

A right ramus bearing P_3-M_3, KUMVP No. 59 (Fig. 7); locality Cedar Creek, northeastern Colorado. The dental pattern of this specimen is almost identical with that of the preceding specimen, No. 5986. It is included here because of the greater size of the teeth and the still persistent double columned M_3. Anteroposterior length of P_3-M_3; 9.2 mm. A left ramus bearing P_3-M_3, KUMVP No. 2879 (Fig. 8); locality, north of Pawnee Buttes, northeastern Colorado. This specimen is slightly smaller than No. 5986 and is similar to it in all respects save that M_3 is a single columned tooth with a small and almost obliterated external reëntrant angle. Again, this is following the sequence as described by Dice and Dice (1935). Anteroposterior length of P_3-M_3; 8.7 mm.

A right ramus bearing P_3-M_3, KUMVP No. 6140 (Fig 9); locality, northeastern Colorado. P_3 is large and the remaining internal reëntrant angle is almost cut off. P_4 is double columned. In M_1, the columns are joined by strip of enamel on the lingual side. M_2 is double columned. M_3 is a single column with an external reëntrant angle extending almost two thirds of the way across the crown of the tooth. Anteroposterior length of P_3-M_3; 10.3 mm.

A left ramus bearing P_3-M_3, KUMVP No. 6138 (Fig. 10); locality, northeastern Colorado. The internal reëntrant angle of P_3 has been cut off and is seen as an enamel lake. P_4 has its columns connected on the lingual side as does M_1. M_2 is approaching this condition. M_3 is a single column with a short external reëntrant angle. Anteroposterior length of P_3-M_3; 9.1 mm.

A left ramus bearing P_3-M_3, KUMVP No. 104 (Fig. 11); locality, Lewis Canyon, northeastern Colorado. This specimen is slightly more advanced in wear than the preceding specimen, No. 6138. Here, M_2 has had its columns connected on the lingual side and M_3 is a peg-like tooth with a very slight external reëntrant angle that will soon disappear. Anteroposterior length of P_3-M_3; 10.3 mm.

Summary on the wear of Lower teeth.—The discrepancies in the various

specimens have been pointed out above. Since material is not available, no definite conclusions can be made as to the normal pattern of wear.

There are two specimens in the collection of the American Museum of Natural History which seem to justify a detailed description. These are AMNH No. 5814 and No. 5790. Both specimens were collected from the Oreodon beds of Cedar Creek, Logan County, Colorado. Specimen No. 5814 is a right ramus bearing P_3-M_3. This specimen resembles KUMVP No. 267 in that its P_3 possesses an anterior reëntrant angle. The posterior internal reëntrant angle, however, opens widely and does not constrict as in the KUMVP specimen. The resemblance stops at this point. P_4, M_1 and M_2 are all relatively young teeth in wear when compared with what is considered young *P. haydeni,* each possessing well developed third lobes. M_3 is double columned, but the columns are just becoming connected about one fifth of the way in from the lingual side by a thin neck of enamel. The posterior column of the tooth possesses a posterior reëntrant angle. I cannot fit this specimen anywhere in the series of dentitional patterns studied. It is unusual in that P_3-M_2 are relatively young in wear pattern and M_3 is just beginning to show signs of old age, that is, when compared with what is considered normal for *P. haydeni.* KUMVP No. 4936 comes close in one respect and that is the possession of the posterior lobe on P_4 and M_2, but this specimen has a double columned M_3. KUMVP No 267 possesses a slight trace of the third lobe of M_2, but in this case, M_3 is well worn, that is, the columns are joined and there is a single external reëntrant angle. AMNH No. 5790, a left ramus bearing P_3-M_3, is also unusual. No anterior reentrant angle is present on P_3. The posterior internal reëntrant angle is just about to close. P_4-M_2 are not unusual, but M_3 is, in that it possesses an enamel lake between the internal and external angles. It is possible to explain this lake in the following way. The outer edge of the enamel of the anterior border of the external reëntrant angle contacts the outer edge of the enamel of the posterior border of the angle, thus pinching off the lake. This is what takes place in the formation of the lingual lake of P_3. I am unable to place this specimen in the series of dental patterns studied. If these, along with the widely differing KUMVP Nos. 4936, 265 and 267 specimens represent a wide range of variation or large number of aberrancies, it is remarkable indeed I believe that further study may show them to be different species than *P. haydeni.*

Table of Measurements in Millimeters of Lower Dentitions of *Palaeolagus haydeni* Leidy

KUMVP No.	Anteroposterior length of P_3-M_3	Depth of ramus at P_3	Depth of ramus at M_3	Width of ramus at P_3	Width of ramus at M_3
6131		4.3*		2.3*	
67	8 6*	5.5*	6 2	3.0*	3.1
6012		6.6*		4.0*	
6136	9.2	6.9	7 8	4.1	3 9
4936	8.1	6.4	7 1	3.3	3.0
70	8.2	6.4	7.7	4 4	3.7
265	9.6	5.9	8.0	4.3	3.9
267	9 9	7.3		4.2	4.1
5986	8.9	6.8	8.6	3.8	3.7
59	9.2	6.1		3.4	3.3
2879	8.7	6.0	8.0	3.3	3.7
6140	10.3	6.7	9.1	3.8	3.9
6138	9.1	7.3	9.0	4.3	4.3
104	10.3	7.0	8.6	4.6	4.2

*dP_3

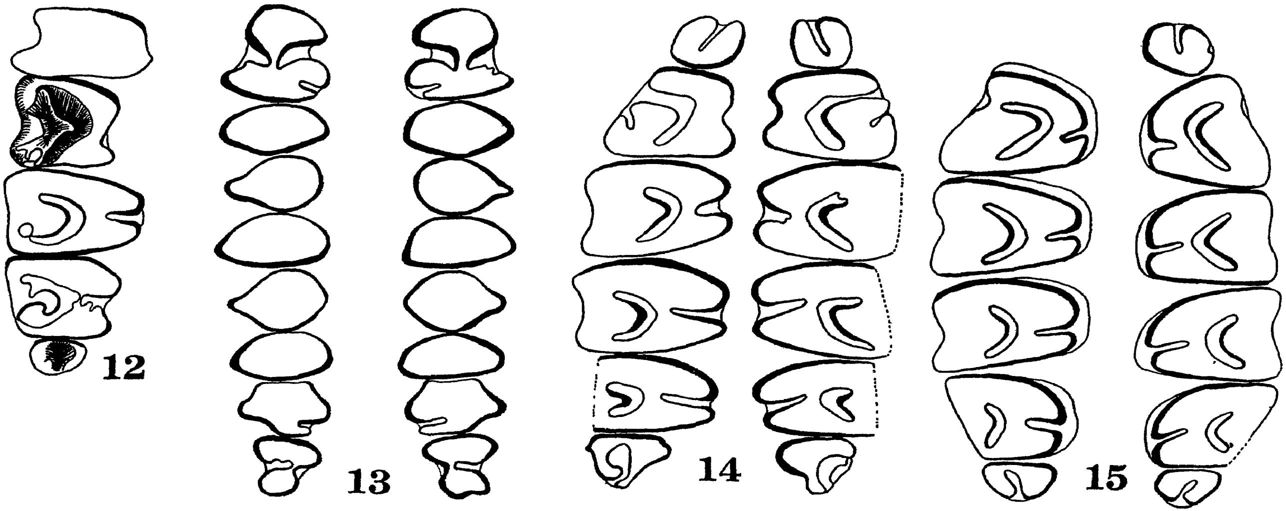
UPPER DENTITIONS

A fragmentary skull bearing $I^{1,2}$, and the right dP^3-M^3, KUMVP no. 107 (Fig. 12); locality, Cedar Canyon, northeastern Colorado. DP^3 is worn almost flat and no reëntrant angles are present. P^3 can be seen coming in underneath. P^4 is just erupting and is unworn. The pattern of the tooth is somewhat ungulate in appearance, the valley of the crescent being rather deep and a well developed valley is present on the lingual side of the crescent. The internal reëntrant angle is short and opens widely. M^1 possesses an internal reëntrant angle which extends almost one third of the way across the crown of the tooth. Slightly anterior to the postero-external end of the crescent is a circular enamel lake. M^2 is slightly less worn, the crescent being irregular in outline. The internal reëntrant angle extends about one third of the way across the crown of the tooth, the posterior border of which is crenulated. M^3 is just beginning to erupt.

A left maxilla bearing P^2-M^1, KUMVP no. 6200; locality, 25 miles northwest of Crawford, Nebraska; horizon, Middle Brule. P^2 has been up only a short while. It is partially broken and no details can be made out about it. The external reëntrant angle of P^3 is bifurcated into an anterior and posterior groove, both having the same opening to the outside. The anterior groove is rather deep and extends across the crown almost to the lingual border of the tooth, then bends postero-labially at an angle of about 90 degrees almost to the posterior border of the tooth. The posterior groove is directed postero-lingually at an angle of about 40 degrees and reaches up to the postero-labially directed portion of the anterior groove. The internal reëntrant angle possesses a wide opening. P^4 is more advanced in wear than P^3. The crescent is deep and wide. A deep groove opposite the bend of the crescent is present but does not open to the outside. This is probably the homologue of the posterior groove of the external reëntrant angle of P^3. The internal reëntrant angle is seen as a widely opening angle not penetrating across the crown very deeply. M^1 has a crescent, opposite the center of which on the labial side is an enamel lake. This, like the valley described in P^4 is probably homologous with the posterior groove of the external reëntrant angle of P^3. Anteroposterior length of P^2-P^4; 5.4 mm., transverse diameter of P^2; 1.3 mm.

A left maxilla bearing P^2-M^2, KUMVP no. 6219; locality, north of Harrison, Nebraska; horizon, Middle Brule. P^2 is barely worn, the ridge between the two anterior reëntrant angles still very cone-like. P^3 shows both grooves of the external reëntrant angle and the internal reëntrant angle. P^4 has a well defined enamel lake on the labial side of the crescent as the remains of what is probably the homologue of the posterior groove of the external reëntrant angle of P^3. M^1 and M^2 show crescents and internal reëntrant angles. Anteroposterior length of P^2-P^4; 4.8 mm., transverse diameter of P^2; 1.5 mm.

A left maxilla bearing P^2-M^2, KUMVP no. 6220; locality, north of Harrison, Nebraska; horizon, Middle Brule. This specimen is slightly older than the preceding specimen. P^2 is barely worn and both anterior reëntrant angles are present. P^3 shows both grooves of the external reëntrant angle and the internal reëntrant angle. P^4 has an enamel lake labiad to the crescent. M^1 and M^2 have well developed crescents and internal reëntrant angles are present. Anteroposterior length of P^2-P^4; 4.8 mm., transverse diameter of P^2; 1.2 mm.



EXPLANATION OF PLATE II

Fig. KUMVP no.

12 107 occlusal view of right dP_3-M_3.

13 Geo. F. Sternberg Collection no. 26, left and right P_3-M_3. Type of *Protolagus affinus* Walker.

14 Geo. F. Sternberg Collection no. 26, right and left P^2-M^3. Type of *Protolagus affinus* Walker.

15 Geo. F. Sternberg Collection no. 206, right and left P^3-M^3 and P^2-M^3 respectively. Paratype of *Protolagus affinus* Walker.

All figures, X 6

A left maxilla bearing P^2-M^3, KUMVP no. 6203; locality, Crawford, Nebraska; horizon, Middle Brule. P^2 possesses both anterior reëntrant angles, the labial one almost gone. P^3 shows an internal reëntrant angle and both grooves of the external reëntrant angle. P^4 shows two small lakes labiad of the crescent. M^1 and M^2 have well developed crescents. M^3 has a posterior reëntrant angle extending across the crown of the tooth almost to the anterior border. This pattern of M^3 is the same as that of the type and paratype of *Protolagus affinus* Walker (Figs. 14 and 15). Anteroposterior length of P^2-M^3; 9.5 mm., transverse diameter of P^2; 1.0 mm.

A fragmentary right maxilla bearing P^2-P^4, KUMVP no. 6214; locality, north of Harrison, Nebraska; horizon, Middle Brule. P^2 shows the lingual and labial anterior reëntrant angles. P^3 has a small internal reëntrant angle and the bifurcated external reëntrant angle. P^4 has a small lake opposite the anterior end of the crescent on the labial side. M^1 and M^2 both have crescents but the crescent of M^2 is on its way to disappearance. Anteroposterior length of P^2-P^4 ; 4.6 mm., transverse diameter of P^2; 1.5 mm.

A fragmentary right maxilla bearing P^2-P^4, KUMVP no. 6204; locality, 25 miles northwest of Harrison, Nebraska; horizon, Middle Brule. P^2 has only one anterior reëntrant angle, the lingual. The labial anterior angle has disappeared due to wear. Only a faint trace of the posterior groove of the external reëntrant angle is present. There is an internal reëntrant angle. P^4 has a crescent and an internal reëntrant angle within which is a small enamel lake. Anteroposterior length of P^2-P^4; 4.9 mm., transverse diameter of P^2; 1.2 mm.

A right maxilla bearing P^4-M^3, KUMVP no. 6194; locality, 25 miles northwest of Crawford, Nebraska; horizon, Middle Brule. P^4 possesses a crescent with two small lakes of enamel on the labial side, one just opposite the anterior end of the crescent, the other just below it opposite the deep curve of the crescent. The crescents are decreasingly smaller in M^1 and M^2. P^4, M^1 and M^2 all have internal reëntrant angles. The posterior reëntrant angle of M^3 is just closing off. Anteroposterior length of M^1-M^3; 4.2 mm.

A left maxilla bearing P^2-M^1, KUMVP no. 6003; locality, Cedar Creek, northeastern Colorado. P^2 is broken but shows a single anterior reëntrant angle. P^3 has a large crescent and a well developed internal reëntrant angle. P^4 has a smaller crescent. In M^1 the crescent is reduced to an elliptical oval and the internal reëntrant angle is almost gone. Anteroposterior length of P^2-P^4; 4.9 mm., transverse diameter of P^2; 1.6 mm.

A left maxilla bearing P^2-M^2, KUMVP no. 6134; locality, northeastern Colorado. P^2 is broken but shows an anterior reëntrant angle. P^3 has a very large crescent and an internal reëntrant angle. P^4 has lost the crescent due to wear and the internal reëntrant angle has almost been cut off to form a lake. M^1 has lost the internal reëntrant angle, only the lake remaining. M^2 has a well developed internal reëntrant angle. There are no crescents in either M^1 or M^2, they having been lost by wear. Approximate anteroposterior length of P^2-M^3; 10.8 mm., transverse diameter of P^2; 1.5 mm.

A right maxilla bearing P^2-M^2, KUMVP no. 6217; locality, north of Harrison, Nebraska; horizon, Middle Brule. P^2 has a single anterior reëntrant angle. P^3 has a well developed crescent with a lake on the lingual side as the remains of the internal reëntrant angle, the lingual part of which is still

visible. P^4 has a smaller crescent and the lake is farther away from it and more of the internal reëntrant angle is present. In M^1, the crescent has disappeared. The lake is a narrow oval and only a trace of the internal reëntrant angle is present. The crescent of M^2 has disappeared due to wear, but there is still a well defined internal reëntrant angle. Anteroposterior length of P^2-P^4; 5.6 mm., transverse diameter of P^2; 1.9 mm.

A left maxilla bearing P^2-M^3, KUMVP no. 6225; locality, 8 miles southwest of Chadron, Nebraska; horizon, Middle Brule. P^2 has a single anterior reëntrant angle. The crescent is small in P^3 and only a lake is left of the internal reëntrant angle. P^4 has yet a smaller crescent and lake. M^1 has only a lake while M^2 has a very small crescent. M^3 is a circular peg. Anteroposterior length of P^2-M^3; 10.6 mm., transverse diameter of P^2; 1.9 mm.

A right maxilla bearing P^2-M^3, KUMVP no. 2881; locality, Custer County, South Dakota. The exact locality and horizon are unknown. P^2 possesses a single anterior reëntrant angle. P^3 has an internal reëntrant angle which extends about one third of the way across the crown of the tooth. The crescent is reduced to a small oval. P^4 has only a slight trace of the internal reëntrant angle, most of it cut off to form an enamel lake. In M^1 the stage of wear is further advanced in that all trace of the internal reëntrant angle is gone and the lake is but a thin elongated oval. M^3 is reduced to a peg-like condition. Anteroposterior length of P^2-M^3; 9.6 mm., transverse diameter of P^2; 2.0 mm.

A left maxilla bearing P^3-M^2, KUMVP no. 6208; locality, north of Harrison, Nebraska; horizon, Middle Brule. The crescent in P^3 is elongated and does not have a very decided "V" shape. The internal reëntrant angle has disappeared because of wear, an enamel lake being all that is left. P^4 presents the same picture but the crescent is smaller. In M^1 and M^2 the crescents have been lost by wear and the enamel lakes are small.

A left maxilla bearing P^3-M^2, KUMVP no. 6212; locality, north of Harrison, Nebraska; horizon, Middle Brule. The crescent of P^3 does not have a very definite "V" shape. All that remains of the internal reëntrant angle is the lake. P^4, M^1 and M^2 have all lost the crescents because of wear. In all three, the internal reëntrant angle is reduced to a lake which decreases in size proceeding posteriorly.

A left maxilla bearing P^2-M^3, KUMVP no. 6216; locality, north of Harrison, Nebraska; horizon, Middle Brule. P^2 is broken and nothing can be told from it. P^3 has only a faint internal reëntrant angle, the major portion being isolated as a lake. The crescent has separated and is found as two lakes, one posterior to the other. P^4 also shows only a faint internal reëntrant angle, most of it isolated as a lake. M^1 and M^2 show only the lake. M^3 is broken.

A fragmentary left maxilla bearing M^1-M^3, KUMVP no. 6202; locality, 25 miles northwest of Crawford, Nebraska; horizon, Middle Brule. There are no crescents on M^1 and M^2. The lakes, the remains of the internal reëntrant angles, are barely visible. M^3 is reduced to a simple peg-like tooth. Anteroposterior length of M^1-M^3; 4.3 mm.

A left maxilla bearing P^2-M^3, KUMVP, no. 6205; locality, 25 miles northwest of Crawford, Nebraska; horizon, Middle Brule. P^2 is broken and nothing can be told from it. P^3 has lost the crescent because of wear. The internal reëntrant angle is gone and all that remains is the lake. M^1 and M^2

have lost all traces of the internal reëntrant angles. M^3 is reduced to a circular peg. Anteroposterior length of P^2-M^3; 10.5 mm.

Table of Measurements in Millimeters of Upper Dentitions of *Palaeolagus haydeni* Leidy

KUMVP No.	Anteroposterior length of P^2-M^3	Anteroposterior length of P^2-P^4	Anteroposterior length of M^1-M^3	Transverse diameter of P^2
107	10.4*†	5.5*	4.8	
6200		5.4		1.3
6219		4.8		1.2
6220		4.6		1.3
6203	9.5	4.7	4.2	1.0
6214		4.6		1.5
6204		4.9		1.2
6195			5.2†	
6194			4.2	
6003		4.9		1.6
6134	10.8†	5.5		1.5
6217		5.6		1.9
6225	10.6	5.5	4.1	1.9
2881	9.8	5.4	4.2	2.0
GFS No. 23 right	10.5	6.6	4.3	1.5
GFS No. 260 left	10.1	5.0	4.7	1.4

*DP^2 †approximate

Palaeolagus burkei Wood, 1940

1940. *Palaeolagus burkei* Wood. The Mammalian fauna of the White River Oligocene, part III, Lagomorpha. Trans. Phil. Soc., n.s., vol. xxviii, pp. 271-362, figs. 71-116, pls. xxxiv, xxxv.

Type locality.—Northeastern Colorado.

Horizon.—Leptauchenia beds.

Specific characters.—The internal reëntrant angles are deep and persist but not closing off until late in life. Wood (1940) states that "There are no crenulations in the hypostria". However, his figure of the type shows a slight trace of the loop found in the KUMVP specimens on its P^4 and M^2. Crescents on the upper molars are absent. If they are present in young specimens, they disappear rapidly with wear.

DESCRIPTION OF SPECIMENS

A right maxilla bearing P^2-M^3, KUMVP no. 163 (Fig. 16); locality, Yuma County, Colorado. This specimen is slightly larger than the type figured by Wood, but is similar to it in having almost exactly the same enamel pattern, the main difference being a small loop on the posterior border of the internal reëntrant angle (hypostria of Wood, 1940) of P^4 and M^2. This loop is possibly indicative of a crenulation. The anterior reëntrant angle of P^2 extends two thirds of the way across the crown of the tooth. Anteroposterior length of P^2-M^3; 8.7 mm., transverse diameter of P^2; 1.6 mm.

A right maxilla bearing P^2-M^2, KUMVP no. 4946 (Fig. 17); locality, Cedar Creek, northeastern Colorado. The anteroposterior length of P^2-P^4 is less than that of specimen no. 163, and also of the type, and the transverse diameter of P^2 is greater than that of the type. The reëntrant angle of P^4 possesses the same loop on the posterior border to a more marked degree than specimen no. 163, but the loop of M^2 is less developed in this specimen. The external reëntrant angle of P^3 does not pass posteriorly beyond the middle of the internal reëntrant angle. It is almost cut off on the outside and indicates an older specimen. The anterior reëntrant angle of P^2 extends one third of

the way across the crown of the tooth. Anteroposterior length of P^2-P^4; 4.0 mm., transverse diameter of P^2; 1.5 mm.

A left maxilla bearing P^2-M^2 and a right maxilla bearing P^2-M^3, KUMVP no. 5987 (Fig. 18); locality, Cedar Canyon, northeastern Colorado. The anterior reëntrant angle of P^2 extends one third of the way across the crown of the tooth. The internal reëntrant angles are persistent and possess no loops. P^3 has lost the external reëntrant angle because of wear. Anteroposterior length of P^2-M^3; 8.0 mm., transverse diameter of P^2; 1.9 mm.

A right maxilla bearing P^2-M^3, KUMVP no. 6105 (Fig. 19); locality, 10 miles northwest of Harrison, Nebraska. The anterior reëntrant angle of P^2 does not extend very far across the crown of the tooth and all indications are that it will disappear with a little more wear. The external portion of P^3 is gone and no indication of the development of the external reëntrant angle can be positively ascertained. The internal reëntrant angles of P^3, P^4 and M^1 show s'gns of closing and possibly, with more wear, lakes will be formed. Anteroposterior length of P^2-M^3; 7.8 mm., transverse diameter of P^2; 1.5 mm.

A left maxilla bearing P^2-M^3 (M^1 absent), KUMVP no. 5988; locality, Cedar Canyon, Colorado. P^4 possesses a loop on the posterior border of the internal reentrant angle as in other specimens. P^3 shows the external reëntrant angle as does no. 163 and the type. The anterior reëntrant angle of P^2 extends about one half way across the crown of the tooth. Anteroposterior length of P^2-M^3; 8.7 mm., transverse diameter of P^2; 1.6 mm.

Palaeolagus cf. *burkei* Wood

A right maxilla bearing P^2-M^2, KUMVP no. 5984; locality, Pawnee Creek, northeastern Colorado; the horizon of this specimen is in doubt owing to incomplete data. It was collected in 1925 by H. T. Martin and catalogued by him as Miocene. However, the field catalogue for that year makes no mention of any specimens having been collected from the Miocene, all other specimens collected at that time being Oligocene in age. P^2 is barely worn and possesses two anterior reëntrant angles, the lingual angle extend'ng across the crown of the tooth almost to the posterior border. The labial angle extends about one half way across the crown of the tooth. P^3 is not much worn. It possesses an internal reëntrant angle with a wide opening which extends about one fourth of the way across the crown of the tooth. The external reentrant angle is not bifurcated and extends about two thirds of the way across the crown of the tooth postero-lingually. P^4 has an internal reëntrant angle with a wide opening, which extends about one fourth of the way across the crown of the tooth. A crescent is present, lab'ad of which is a groove similar to that found on the P^4 of *P. haydeni.* M^1 has an internal reëntrant angle which extends almost one half way across the crown of the tooth. It has a small loop on the posterior border of the internal reentrant angle as seen in specimens of *P. burkei.* There is no crescent. Anteroposterior length of P^2-P^4; 5.0 mm., transverse diameter of P^2; 1.3 mm.

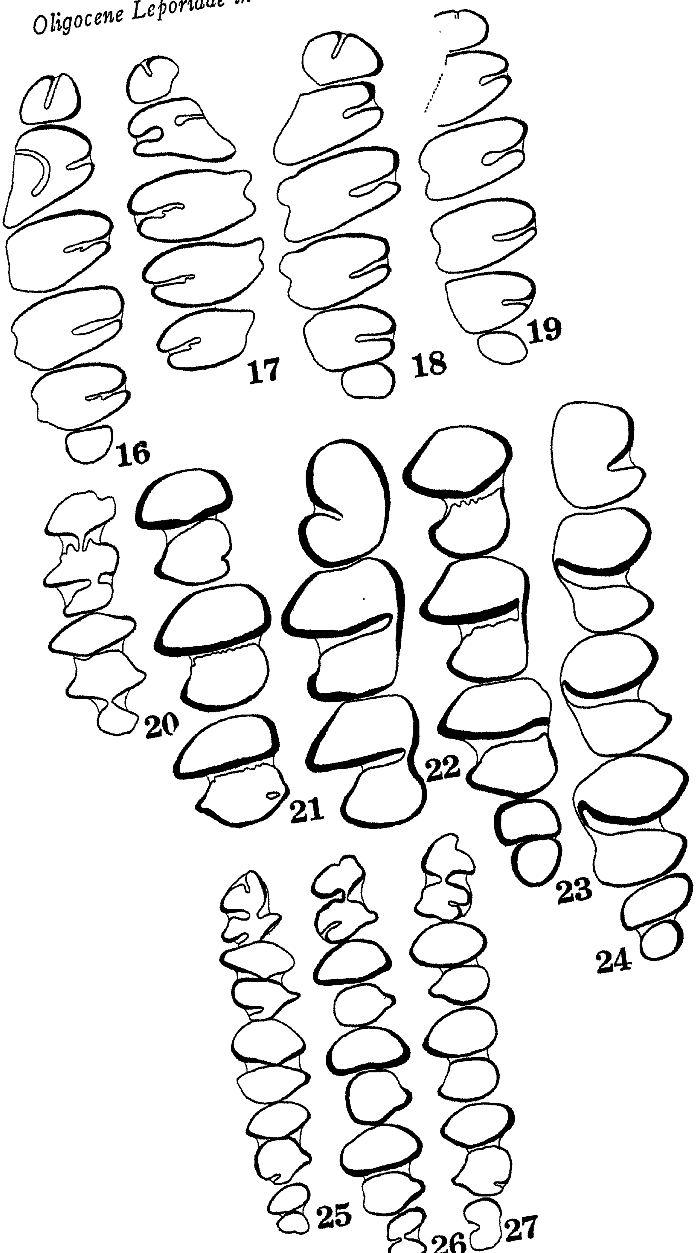
This specimen does not fit in the *P. haydeni* series. The relative age of P^2 to M^2 does not correspond, that is, M^2 at this stage of wear in *P. haydeni* has a P^2 that is well worn. An old appearing M^2 with a young appearing P^2 is to be expected in *P. burkei* because of the early loss of crescents, if it ever possesses them. The absence of the posterior groove of the external reëntrant angle of P^3 is a further indication that it is not *P. haydeni.* The presence of

EXPLANATION OF PLATE III

Fig.	KUMVP no.	
16	163	occlusal view of right P^2-M^3.
17	4946	occlusal view of left P^2-M^2.
18	5987	occlusal view of right P^2-M^3.
19	6105	occlusal view of right P^2-M^3.
20	266	occlusal view of left dP_3-dP_4.
21	118	occlusal view of left P_4 M_2.
22*	6226	occlusal view of left P_3-M_1.
23*	268	occlusal view of left P_4-M_3.
24	63	occlusal view of right P_3-M_3.
25	4936	occlusal view of right P_3-M_3.
26	265	occlusal view of right P_3-M_3.
27	267	occlusal view of left P_3-M_3.

All figures, X 6

*Reverse order for correct wear pattern.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the loop on the posterior border of the internal reëntrant angle of M^2 is an indication of its being *P. burkei.* Since there are no specimens in the collection with which to bridge the gap between this specimen and specimen no. 163, only a provisional assignment of this specimen to *P. burkei* is made.

Table of Measurements in Millimeters of *Palaeolagus burkei* Wood

KUMVP No.	Anteroposterior length of P^2-M^3	Anteroposterior length of P^2-P^4	Anteroposterior length of M^1-M^3	Transverse diameter of P^2
163	8.7	4.6	4.0	1.6
5988	8.7	4.3	3.9	1.6
4946		4.0		1.5
6105	7.8	4.1	3.6	1.5
5987 left	8.5*	4.0	4.3*	1.6
5987 right	8.0	4.1	3.6	1.9
AMNH No. 8704 holotype	7.5*	4.8*	3.4*	1.39

*approximate

Discussion.—The specimens in the Kansas University Museum of Vertebrate Paleontology are all larger than the type of *P. burkei.* The anteroposterior length of the type was approximated by measuring the figure of the type (Wood, 1940) and dividing by five. The same method was used in ascertaining other measurements. It will be seen that the measurements have no consistent direct correlation with age, indicating a wide degree of individual variation. P^2 does not seem to present any unusual reduction in the KUMVP specimens. It may be inferred that the holotype is a rather small though relatively mature specimen.

It may be considered that the most important character of the upper teeth of *P. burkei* is the long persistence of the internal reëntrant angles.

No lower jaws of *P. burkei* are known. Undoubtedly, they exist, either as unidentified or misidentified specimens in collections. It is possible that some or one of the questionable lower jaws of *P. haydeni* may be the lower of *P. burkei.*

The vertical range of *P. burkei* needs to be extended as a result of this study if specimen no. 6105 which is from the Middle Brule clay of Nebraska has been correctly identified. The other specimens assigned to *P. burkei* are from the northeastern part of Colorado and are probably from the Cedar Creek beds. No detailed data are available on these specimens which were collected chiefly by H. T. Martin and parties in 1911 and 1925.

Megalagus Walker, 1931

1873. *Palaeolagus turgidus* Cope. Third notice of extinct Vertebrata from the Tertiary of the Plains. Palaeo. Bull. no. 16, pp. 1-8.

1931. *Megalagus turgidus* (Cope), Walker. Notes on North American fossil lagomorphs. The Aerend, vol. II, no. 4, pp. 227-240, 1 pl.

Megalagus

Generic diagnosis.—P^3 has a single internal reëntrant angle which soon disappears because of wear. The columns of P_4-M_2 are joined lingually by an enamel strip early in life. The internal reëntrant angles of P^3-M^2 are not maintained for as long a period of life as in *Palaeolagus.* M^3 remains double columned throughout the greater part of life. In addition, *Megalagus* is much larger than any of the species of *Palaeolagus* known.

Megalagus turgidus (Cope)

1873. *Palaeolagus turgidus* Cope. Third notice of extinct Vertebrata from the Tertiary of the Plains. Palaeo. Bull. no. 16, pp. 1-8.

1873. *Palaeolagus triplex* Cope. Third notice of extinct Vertebrata from the Tertiary of the Plains. Palaeo. Bull. no. 16, pp. 1-8.

1873. *Tricium paniense* Cope. Third notice of extinct Vertebrata from the Tertiary of the Plains. Palaeo. Bull. no. 16, pp. 1-8.

1931. *Megalagus turgidus* (Cope), Walker. Notes on North American fossil lagomorphs. The Aerend, vol. II, no. 4, pp. 227-240, 1 pl.

Type locality.—Probably northeastern Colorado.

Horizon.—Middle Oligocene.

Specific characters.—Larger than all known leporids of Oligocene age. The teeth of *Megalagus turgidus* (Cope) are more hypsodont than those of *Megalagus brachyodon* (Matthew). The reëntrant angles of the upper molars are more persistent than in *M. brachyodon.*

DESCRIPTION OF SPECIMENS

A fragmentary left ramus bearing dP_3 (broken), dP_4, M_1 and M_2 (part), KUMVP no. 266 (Fig. 20); locality, Hat Creek Basin, northwest Nebraska. The broken dP_3 shows two roots. DP_4 is also two rooted and not much worn. It is three columned; the first and second columns are connected in the center by a thin neck of enamel. M_1 is also three columned, differing from dP_4 in that the first and second columns are not connected and the third column is much smaller.

A fragmentary left ramus bearing P_4-M_2, KUMVP no. 118 (Fig. 21); locality, Lewis Canyon, Colorado. P_4 shows a faint trace of the third lobe. It is gone in M_1 and M_2, but M_2 has a small lake on the labial side of the posterior column as all that remains of the third lobe. The specimen though young is large.

A fragmentary left ramus bearing P_3-M_3, KUMVP no. 268 (Fig. 23); locality, Hat Creek Basin, Nebraska. The lingual sides of the columns of P_4 are not quite connected, connected in M_1 and almost connected in M_2. M_3 is double columned, the columns separated from each other by a thin band of cement. P_3 is broken.

A right ramus bearing P_3-M_3, KUMVP no. 63 (Fig. 24); locality, Cedar Creek, northeastern Colorado. A small specimen is indicated by the antero-posterior length of the tooth row, but it is robust in other respects. P_3 possesses a single external reëntrant angle. P_4, M_1 and M_2 each have their anterior and posterior columns connected by enamel on the lingual side. M_3 has two columns.

A fragmentary left ramus bearing P_3-M_1, KUMVP no. 6226 (Fig. 22); locality, 8 miles southwest of Chadron, Nebraska. This specimen shows the typical dental pattern of old age. P_3 possesses a single external reëntrant angle. The anterior and posterior columns of P_4 and M_1 are connected lingually by a thick band of enamel.

Table of Measurements in Millimeters of *Megalagus turgidus* (Cope)

KUMVP Nos.	266	118	268	63	6192	6226	Type[1]
Anteroposterior length of P_3-M_3				12.7			16.0
Anteroposterior length of P_3-M_1				8.4		9.0	
Anteroposterior length of M_1-M_3			7.6	7.3			
Depth of ramus at P_3	7.6*		9.1	8.4	9.9		
Depth of ramus at M_1	7.9	8.7	9.8	9.8			10.0
Depth of ramus at M_3		9.9	10.9	10.5			
Width of ramus at P_3	4.6*†		5.5	5.8	6.6	4.6	
Width of ramus at M_1		5.9	4.7	5.2			3.5
Width of ramus at M_3		4.8	5.2	4.7			

[1]From Cope (1873c). *dP_3. †approximately.

A left maxilla bearing P^2-M^3, KUMVP no. 2799; loçality, northeastern Colorado. This specimen is the only maxilla of *M. turgidus* in the collection. P^2 possesses two anterior reëntrant angles. P^3 shows a large crescent and a trace of an internal reëntrant angle. The crescent of P^4 is smaller than in P^3. M^1 has a horseshoe shaped crescent and an internal reëntrant angle that reaches almost to it. In M^2 the same condition prevails as in M^1 except that the tooth is smaller. M^3 is broken, but what can be seen of it reveals an oval peg. Approximate anteroposterior length of P^2-M^3; 14.1 mm., anteroposterior length of P^2-P^4; 6.3 mm., transverse diameter of P^2; 2.3 mm.

SUMMARY

The Oligocene Leporidae of the Kansas University Museum of Vertebrate Paleontology collection include two genera and three species, the majority of which are probably from the Middle Oligocene. A large number of fragmentary rami and maxillae have not been identified.

REFERENCES

Burke, J. J. 1934. *Mytonolagus*, a new leporine genus from the Uinta Eocene series in Utah. Ann. Carnegie Mus., vol. xxiii, pp. 399-420, 1 pl.

———. 1936. *Ardynomys* and *Desmatolagus* in the North American Oligocene. Ann. Carnegie Mus., vol. xxv, pp. 135-154, 7 figs.

1941. New Fossil Leporidae from Mongolia. Amer. Mus. Novitates, no. 1117, pp. 1-23, 9 figs.

Cope, E. D. 1873a. Second notice of extinct Vertebrata from the Tertiary of the Plains. Palaeontological Bulletin no. 15, pp. 1-6.

———. 1873b. Synopsis of new Vertebrata from the Tertiary of Colorado, obtained during the summer of 1873. Washington, Government Printing Office, pp. 1-9.

———. 1873c. Third notice of extinct Vertebrata from the Tertiary of the Plains. Palaeontological Bulletin no. 16, pp. 1-8.

———. 1874. Report on the Vertebrate Palaeontology of Colorado. Ann. Rept. Geol. and Geog. Surv. Terr. for 1873, pp. 427-533, pls. i-viii.

———. 1881. The Rodentia of the American Miocene. Amer. Naturalist, xv, pp. 586-587.

———. 1882. Review of the Rodentia of the Miocene period of North America. Bull U.S. Geol. and Geog. Surv. Terr., vi, article xv, pp. 361-386.

Cope, E. D. 1883. The extinct Rodentia of North America. Amer. Naturalist, xvii, pp. 43-57, 165-174, 370-381, fig. 20.

——. 1884. The Vertebrata of the Tertiary formations of the West. Rept. U.S. Geol. Surv. Terr., III, pp. i-xxxv, 1-1009, pls. i-lxxva.
——. 1885. The White River Beds of Swift Current River, Northwest Territory, Am. Naturalist, xix, p. 163.
1889. The Vertebrata of the Swift Current River II. Amer. Naturalist, xxiii, pp. 151-155.
Dice, L. R. 1917. Systematic position of several American Tertiary Lagomorphs. Univ. Calif. Publ. Bull. Dept. Geol., x, no. 12, pp. 179-186, 6 figs.
————. 1929. The phylogeny of the Leporidae, with a description of a new genus. Journ. Mammalogy, vol. 10, no. 4, pp. 340-344.
————. 1933. Some characters of the skull and skeleton of the fossil hare, *Palaeolagus haydeni.* Papers, Mich. Ac. Sci., Arts and letters, vol. xviii, pp. 301-305, 2 pls.
and Dice, D. S. 1935. The lower cheek teeth of the fossil hare, *Palaeolagus haydeni.* Papers, Mich. Ac. Sci., Arts and Letters, vol. xx, pp. 455-463, figs. 7-25, pl. xciii.
Douglass, E. 1901. Fossil Mammalia of the White River Beds of Montana. Trans. Am. Phil. Soc., (2), xx, pp. 237-279, pl. ix.
————. 1909. A geological reconnaissance in North Dakota, Montana and Idaho. Ann. Carnegie Mus., v, pp. 211-288, pls. xv-xxi.
Hay, O. P. 1902. Bibliography and Catalogue of the fossil Vertebrata of North America. U.S. Geol. Surv., Wash. Government Printing Office.
————. 1929. Second Bibliography and Catalogue of the fossil Vertebrata of North America. Carnegie Institution of Washington. Publ. no. 390, vol. I, vol. II, 1930.
Hibbard, Claude W. 1939. Four new rabbits from the Upper Pliocene of Kansas, Amer. Mid. Nat., vol. 21, no. 2, pp. 506-513, 4 figs.
Leidy, J. 1856. Notices of remains of extinct Mammalia, discovered by Dr. V. F. Hayden in Nebraska Territory. Proc. Phila. Acad. Sci., viii, pp. 89-90.
————. 1869. The extinct Mammalian fauna of Dakota and Nebraska. Journ. Ac. Nat. Sci. Phila., pp. 331-404, pl. xxvi, figs. 14-20.
1871. Report on the Vertebrate fossils of the Tertiary formations of the West. U.S. Geol. Surv. of Wyoming and portions of contiguous territories. 2nd (4th) ann. rept., F. V. Hayden, U.S. Geologist, pp. 340-370.
Major, C. J. F. 1899. On fossil and recent Lagomorpha. Trans. Linn. Soc. Lond. (2), vii, pp. 433-520, pls. xxxvi-xxxix.
Matthew, W. D. 1899. A provisional classification of the fresh-water Tertiary of the West. Bull. Am. Mus. Nat. Hist., xii, pp. 19-75.
————. 1902. A horned rodent from the Colorado Miocene, with a revision of the Mylagauli, Beavers and Hares of the American Tertiary. Bull. Am. Mus. Nat. Hist., xvi, pp. 291-310.
————. 1903. The fauna of the Titanotherium Beds at Pipestone Springs, Montana. Bull. Am. Mus. Nat. Hist., vol. xix, art 6, pp. 197-226, 19 figs.
and Grainger, W. 1923. Nine new rodents from the Oligocene of Mongolia. Am. Mus. Novitates, no. 102, pp. 1-10, 12 figs.
Trouessart, E. L. 1898. Catalogus Mammalium.
————. 1904. Catalogus Mammalium Supplementum.
Troxell, E. L. 1921. *Palaeolagus,* an extinct hare. Am. Journ. Sci., (5), 1, pp. 340-348, 20 figs.
Walker, M. V. 1931a. Notes on fossil Lagomorpha Trans. Kansas Acd. Sci., vol. 34, pp. 122-124.
————. 1931b. Notes on North American fossil Lagomorpha. The Aerend, vol. II, no. 4, pp. 227-240, 1 pl.
Wood, A. E. 1940. The Mammalian fauna of the White River Oligocene, part III, Lagomorpha. Trans. Amer. Phil. Soc., n.s., vol. xxviii, pp. 271-362, figs. 71-116, pls. xxxiv, xxxv.
Wood, H. E., et al. 1941. Nomenclature and correlation of the North American continental Tertiary. Bull. Geol. Soc. Amer., vol. 52, pp. 1-48, 1 pl.

26

The Occurrence of Eucastor Tortus Leidy in Phillips County, Kansas

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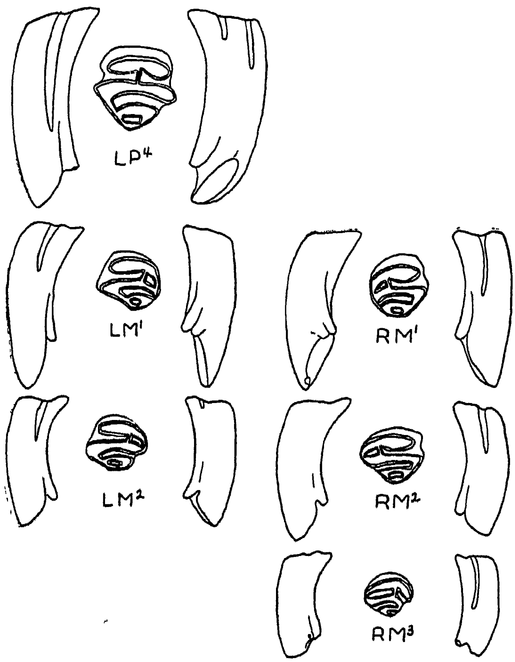
INTRODUCTION

In the fall of 1939 Mr. Childs Frick kindly forwarded to the Museum of Vertebrate Paleontology his collection of Kansas rodents for study. I am grateful to Mr. Frick for the privilege of studying and reporting upon this material. In the collection was a fragmentary maxillary of *Eucastor* from Phillips county, Kansas. The occurrence of this Lower Pliocene form helps to establish proof of the presence of deposits of that age in Kansas.



EXPLANATION FOR PLATE I

Eucastor tortus Leidy, No. 24622 F:A.M.N.H., lingual, occlusal and labial views of upper molars, twice natural size. (Drawings by Frances Watson).

Eucastor tortus Leidy 1858

Plate I

The specimen consists of the fragmentary maxillaries bearing LP^4-M^2; and RM^1-M^3, F:A.M. no. 24622. The specimen was collected by George Sternberg, 1933, on the Selbe Ranch, eight miles northeast of Phillipsburg, Phillips county,

Kansas. It is slightly smaller than the type with which it has been compared, though the difference in dentitional pattern is considered only as age difference in wear. The much reduced M^3 seems to correspond with the condition that existed in the type from the study of the alveolus. Following is a description of the dentition of this specimen.

LP^4 with two external striae. Parastria longer 3.0 mm.; mesostria, 1.5 mm. in length. Metastria completely worn off; hypostria, 8.6 mm. in length. LM^1 without any external stria; hypostria present, 3.4 mm. in length. Parafossette adjacent to hypoflexus; mesofossette and metafossette present. LM^2 with shallow mesostria, hypostria well developed, parafossette adjacent to hypoflexus; metafossette present. RM^1 without any external stria, hypostria present, 3.6 mm. in length. Parafossette adjacent to hypoflexus; mesofossette and metafossette present. RM^2 with mesostria 0.9 mm. in length, hypostria 4.0 mm. in length, parafossette adjacent to hypoflexus; metafossette present. RM^3 with mesostria very shallow, hypostria 3.2 mm. in length, parafossette adjacent to hypoflexus, mesoflexus strongly curved and metafossette present. Palatal foramina opposite M^2 as in *Eucastor planus* Stirton, but smaller. Width of palate between fourth premolars, 3.0 mm.

Following is a list of some Pliocene mammals from northwestern Kansas that are not known to occur in the Edson fauna and are considered to be Lower Pliocene in age.

Aelurodon sp. In the KUMVP collection are two specimens referable to this genus, a humerus No. 3775 collected in Rawlins county, Kansas, and the other a right ramus, No. 3733, bearing P_3-M_1, collected in Logan county, Kansas. These remains are considered to be Lower Pliocene in age.

Machairodus catocopis Cope 1887. This species is not known from the Edson quarry and Rhino Hill faunas Type locality, Phillips county, Kansas, found by Frank Hazard.

Mylagaulus sesquipedalis Cope 1878a. Type collected by R. S. Hill in the Loup Fork beds=Ogallala, of northwestern Kansas.

Epigaulus hatcheri Gidley 1907. A nearly complete skeleton; the type (cat. no. 5485 U.S.N.M.) was collected by John Bell Hatcher in 1885 near Long Island, Phillips county, Kansas.

Aphelops malacorhinus Cope 1878. Type collected by R. S. Hill from Loup Fork=Ogallala, of northwestern Kansas.

Nannippus retrusus (Cope) 1889. The type of this horse was described by Cope under the genus *Hippotherium* from Phillips county, Kansas, collected by Frank Hazard.

Pliohippus nobilis Osborn 1918. The type was collected by the American Museum Expedition of 1894 near Long Island, Phillips county, Kansas.

The following *Oreodonts* recently reported by Schultz and Falkenbach (1941) from Norton county, Kansas, help to substantiate the presence of Lower Pliocene deposits in this area.

Ustatochoerus medius medius (Leidy) 1858.

A skull with mandible and the distal end of a humerus are listed by Schultz and Falkenbach, (p. 32) that were collected 2 miles south of Densmore, Norton county, Kansas.

Ustatochoerus profectus profectus (Matthew and Cook) 1909.

A partial skull and mandible and skeletal fragments are listed by Schultz and Falkenbach, (p. 43) from southeast of Densmore, Norton county, Kansas.

Ustatochoerus skinneri skinneri Schultz and Falkenbach 1941.

A mandible, partial humerus, 2 radii, 2 ulnae, manus and pes elements of this oreodon from southwest of Lenora, Norton county, Kansas, are reported by Schultz and Falkenbach (p. 48).

Trilophodon dinotherioides Andrews 1909. Type, no data, except "northwestern Kansas".

Tetralophodon campester Cope 1878b. Type from Republican River horizon =Ogallala, Sappa Creek, Rawlins county, Kansas.

Ocatientinus (Serridentinus) republicanus Osborn 1926. Type, no data, except "Republican River formation"=Ogallala, northwestern Kansas.

Remarks.—Simpson (1933, p. 107) definitely recognized the Lower Pliocene as occurring in northwestern Kansas, and he points out the inadequate work that has been done in this region which has led to much confusion. Stirton (1936, p. 188) questioned the age of the so-called "Long Island fauna" and states that "some specimens of *Nannippus gratum* (Leidy)—Cope, 1889, pp. 445-447) and *Eucastor*—(Stirton 1935A, p. 439) from Northern Kansas—probably belong to a Lower Pliocene fauna." Any one interested in a study of the early history of the work in this area is referred to Stirton's (1936) list of literature cited under Long Island.

In the summer of 1931 William K. McNown and myself worked a quarry on the Edgar farm, 5 miles west and one-fourth mile south of Reamsville in Smith county, Kansas. From this quarry were collected remains of *Teleoceros fossiger* (Cope). No forms were recovered that were typical of the Edson Quarry fauna of Sherman county or Rhino Hill fauna of Wallace county, Kansas, both of which are considered as Middle Pliocene in age. After working in Smith county we moved to Phillipsburg, Kansas, where we collected, 6 miles west and seven-eighths of a mile north of the town in Phillips county, a skull of *Serridentinus* and *Teleoceros fossiger* from the same horizon. We were convinced at the time that we were working with an older phase of the Pliocene than was known from Sherman and Wallace counties.

The forms from northwestern Kansas of Lower Pliocene age can not be considered as part of the Long Island fauna, since a real fauna has not been recovered from the Long Island quarries; if such has ever been recovered it has never been reported and only a few forms have been mentioned—a situation which does not give a clear picture of the mammalian assemblage. In northwestern Kansas there may exist deposits ranging throughout the Lower and Middle Pliocene. From the scant knowledge at hand on the Pliocene deposits of Kansas it appears that the Lower Pliocene deposits in northwestern Kansas are widespread, and here and there in regions where they have been eroded away we find deposits of Middle Pliocene, also in other areas the Middle Pliocene is channeled into the Lower Pliocene or laid down over it. In many places there is a veneer of Pleistocene that covers much of the Pliocene deposits, which has been confused with the Ogallala. Owing to the similarity of the Lower and Middle Pliocene deposits in northwestern Kansas they have never been carefully studied and have been considered too often as being of the same age. It also appears that the Middle Pliocene is confined to a more westward portion of that area. The majority of known forms from

northwestern Kansas are of little or no value in correlation because the horizons from which they have been collected are unknown; likewise the vertical ranges of the forms have not been worked out, and until the stratigraphy and vertebrate fossils of that area have been carefully studied little or no progress can be made. What is known of the Long Island fauna proper appears to be different and apparently older than the Edson Quarry fauna.[1] The dominance of the long-legged rhino *Aphelops mutilus* Matthew in the Edson fauna and the short-legged rhino *Teleoceros fossiger* (Cope) at Long Island seems to be of importance, as well as the other associated forms. Though it has never been reported, since jaws were never recovered, there does occur a short-legged rhino in the Edson fauna, rare, which we believe to be *T. fossiger*. In the Rhino Hill quarry only abundant *Aphelops mutilus* remains were found. Rhino Hill quarry is only across the Smoky Hill River in Wallace county from the Edson Quarry but topographically it lies slightly higher.

LITERATURE CITED

ANDREWS, CHARLES W. 1909. Note on the Mandible of a new species of *Tetrabelodon* from the Loup Fork beds of Kansas. Geol. Mag., N.S., vol. 6, pp. 347-349.

BARBOUR, ERWIN HINCHLEY and HIBBARD, CLAUDE W. 1941. A Shovel-Tusked Mastodon, *Amebelodon fricki,* from Kansas. Bull. Univ. Nebr. State Mus., vol. 2, no. 4, pp. 44, 45.

COPE, E. D. 1878A. Description of new extinct Vertebrata from the Upper Tertiary and Dakota formations. Bull. U. S. Geol. and Geog. Surv. Territories, vol. 4, p. 384.

1878B Descriptions of new vertebrata from the Upper Tertiary formations of the West. Proc. Amer. Philos. Soc., vol. 17, pp. 219-231.

1887. A saber-tooth tiger from the Loup Fork beds. Amer. Naturalist, vol. 21, no. 11, pp. 1019-1020.

1889. A Review of the North American Species of *Hippotherium*. Proc. Amer. Philos. Soc., vol. 26, p. 446.

GIDLEY, JAMES WILLIAMS. 1907. A New horned Rodent from the Miocene of Kansas. Proc. U. S. Nat. Mus., vol. 32, no. 1554, pp. 627-636, 8 pls.

HIBBARD, CLAUDE W. 1939. Notes on additional Fauna of Edson Quarry of the Middle Pliocene of Kansas. Trans. Kansas Acad. Sci., vol 42, pp. 460-461.

LEIDY, J. 1858. Notice of some remains of extinct vertebrata, from the valley of the Niobrara River, collected during the exploring expedition of 1857, in Nebraska, under the command of Lieut. G. K. Warren, U. S. Top. Eng., Proc. Acad. Nat. Sci. Phila., vol. 10, pp. 23, 26.

MATTHEW, W. D. and COOK, HAROLD. 1909. A Pliocene fauna from western Nebraska. Bull. Amer. Mus. Nat. Hist., vol. 26, Art. 27, p. 395.

OSBORN, HENRY FAIRFIELD. 1918. Equidae of the Oligocene, Miocene, and Pliocene of North America, Iconographic type Revision. Memoirs Amer. Mus. Nat. Hist., N.S., vol. 2, pt. 1, pp. 160-161.

1926. Additional new Genera and species of the Mastodontoid Proboscidea. Amer. Mus. Nat. Hist. Nov., no. 238, p. 6.

1936 Proboscidea. Amer. Mus. Nat. Hist. Special Publ., vol. 1, pp. 291, 369, 415.

SCHULTZ, C. BERTRAND and FALKENBACH, CHARLES H. 1941. *Ticholeptinae,* a New Subfamily of Oreodonts. Bull. Amer. Mus. Nat. Hist., vol 79, Art. 1, pp. 32, 43, 48.

[1]For a list of this fauna see Hibbard, Claude W., 1939, and Taylor, E. H., 1941.

SIMPSON, GEORGE GAYLORD. 1933. Glossary and Correlation Charts of North American Tertiary Mammal-Bearing Formations. Bull. Amer. Mus. Nat. Hist., vol. 67, p. 107.

STIRTON, R. A. 1935. A Review of the Tertiary Beavers. Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 23, no. 13, p. 439.

1936. Succession of North American Continental Pliocene Mammalian Faunas. Ameri. Jour. Sci., vol. 32, no. 189, pp. 187-188.

1940. Phylogeny of North American Equidae. Bull. Dept. Geol. Sci., vol. 25, no. 4, pp. 165-198, 52 figs., 1 chart.

TAYLOR, E. H. 1941. Extinct toads and salamanders from Middle Pliocene beds of Wallace and Sherman Counties, Kansas. State Geol. Surv. Kans., Bull. 38, pt. 6, pp. 177-196, figs. 1-7.

27

A New Fossil Ground Squirrel Citellus (Pliocitellus) Fricki From the Pliocene of Clark County, Kansas

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INTRODUCTION

Among the fossils collected for the Frick Laboratory by George F. Sternberg from the J. Swayze quarry in Clark county, Kansas, is a skull, left mandible and parts of a skeleton of a ground squirrel. Mr. Sternberg observes in regard to the specimen, "I have spent the whole week . . . opening . . . platform on the southwest corner of the quarry. . . . This A.M. while working with a larger pick above the layer, I turned over a rock with a fine skull of rodent on it. . . ." The rock mentioned is the "mortar bed" capping the deposits of the area. It is chiefly consolidated sand, high in calcium carbonate. From the position of the squirrel in relation to the rock, type of preservation and the matrix around it and in the brain case, which correspond to the texture of the rock and underlying matrix there seems to be no question but that the squirrel is of the same age as the deposits and did not burrow into the deposit at a later date.

I am grateful to Mr. Frick for being allowed to study and describe the following specimen, and to Charles D. Bunker of the Kansas University Museum of Birds and Mammals and E. A. Goldman of Biological Survey, Division of Wildlife Research, for the loan of comparative material. I take pleasure in naming this species for Mr. Frick.

Pliocitellus subgen. nov.
Citellus fricki sp. nov.
(Plates 1 & 2.)

Holotype.—F:A.M. no. 24627, Frick collection, American Museum of Natural History. Skull, (old adult) I, P^4-M^3, lacking squamosals and jugals; left ramus, and I, P_4-M_2, right humerus, radius and ulna, articulated left humerus, radius and ulna and some carpal bones, one left tibia, one partial right tibia; metapodials, carpals, tarsals and ribs. Collected 1939 by George F. Sternberg.

Horizon and type locality.—Middle Pliocene of the Ogallala formation, J. Swayze quarry, Clark county, Kansas.

Type of the Subgenus.—Pliocitellus; Citellus fricki. The characters of the subgenus are those of the type species.

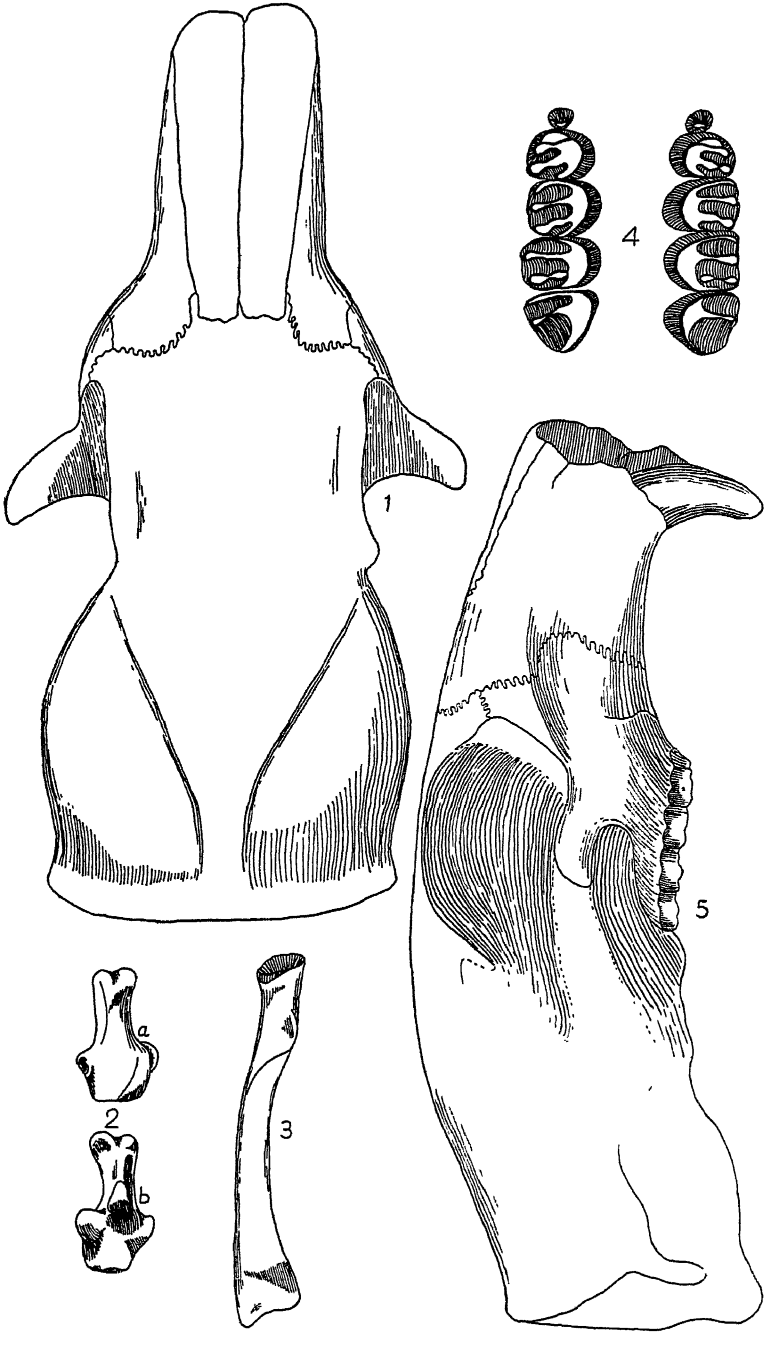
Diagnosis.—A squirrel slightly larger than *Citellus franklinii* (Sabine) with slender, narrow, rounded brain case flattened on top; with slight postorbital constriction; well-developed postorbital processes; interorbital breadth greater than postorbital constriction; supraorbital foramina present; broad rostrum; upper molars, slightly convergent posteriorly, shorter crowned than those of *Citellus variegatus grammurus* (Say); upper molars broader than long; parastyle ridge on P^4, M^1, M^2, and M^3 rising evenly to join the protocone but

separated by a well developed valley; M^3 lacking metaloph; P^3 peg-like, no cutting edge and one-fourth or less than the size of P^4; antorbital canal present, but small; antorbital process of maxillary weakly developed, incisive pits at base of incisors anterior and lateral to incisive foramen well developed and nearly as large as in *Citellus parryii parryii* (Richardson); and upper incisors not recurved as in the subgenus *Ictidomys*. Lower jaw distinct; lower incisor broad dorsoventrally; paraconulid lacking on P_4, tooth narrowed anteriorly with slight groove on anterior face between protoconid and paraconid; M_2 decidedly triangular with the apex at the paraconid, the entoconid crowded close to the paraconid; mandibular foramen lies on the ridge running from posterior to M_3 to the condyle; condyle resembles that of *Sciurus* more than that of *Citellus*.

Description of type.—The type is a skull slightly broken, left ramus lacking M_3, and portions of the skeleton, of an old adult squirrel; the age being based upon the dentitional wear. A study of the material shows the squirrel to have been about the size of *Citellus franklinii*. The skull is in good shape with only the bullae, squamosals, jugals, and postorbital processes lacking. The length of the skull from the tip of the nasals to the posterior edge of the occipital condyles is 57.6 mm. The brain case is narrow, slender and rounded, flattened on top as *C. franklinii*. The greatest breadth of the brain case is 21.6 mm. though the squamosals are lacking. The postorbital constriction has a breadth of 15.8 mm. while the interorbital breadth is 16 5 mm. Only the base of the right postorbital process is present though it is strong and well developed. The zygomatic process of the maxilla is heavy and broad as in *C. variegatus grammurus* and flattened, that is, approaching the horizontal plane of the skull and not as steep as in *Sciurus* though the rostrum is heavier and the nasals longer. The posterior border of the zygomatic process of the maxillary ends opposite the anterior edge of M^1. The supraorbital foramina are present, though broken, so that it may be questioned whether or not they were completely surrounded by bone. The nasals extend well past the incisors. Transverse width of upper incisors is 1.9 mm.; depth anteroposteriorly is 3.6 mm. The posterior borders of the incisive foramina are 10.5 mm. from the anterior edge of P^3. Length of diastema is 14.5 mm. The width of the palate between right and left P^3 is 8.7 mm. The width of the palate between both right and left P^4 and M^1 is 7 6 mm. The left M^2 and M^3 have shifted slightly outward but the distance between right M^3 and left M^3 could not have been over 6.4 mm., so there is only a slight convergence of the maxillary tooth rows. The maxillary tooth row is 10.7 mm. in length. P^3 is peg-like without a cutting surface. The protocone of P^4, M^1, M^2 and M^3 well developed and gives

EXPLANATION OF PLATE I

Fig.
1. *Citellus (Pliocitellus) fricki,* nov. subgen. and sp., holotype No. 24627 F:A.M., dorsal view of skull, twice natural size.
2a-b. Left calcaneum of holotype of *Citellus (Pliocitellus) fricki*, one and one-half times natural size.
3. Right radius of holotype of *Citellus (Pliocitellus) fricki,* one and one-half times natural size.
4. Occlusal view of upper cheek teeth of holotype, three times natural size.
5. Lateral view of skull of holotype of *Citellus (Pliocitellus) fricki,* twice natural size. (Drawings by Frances Watson)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1
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a
2
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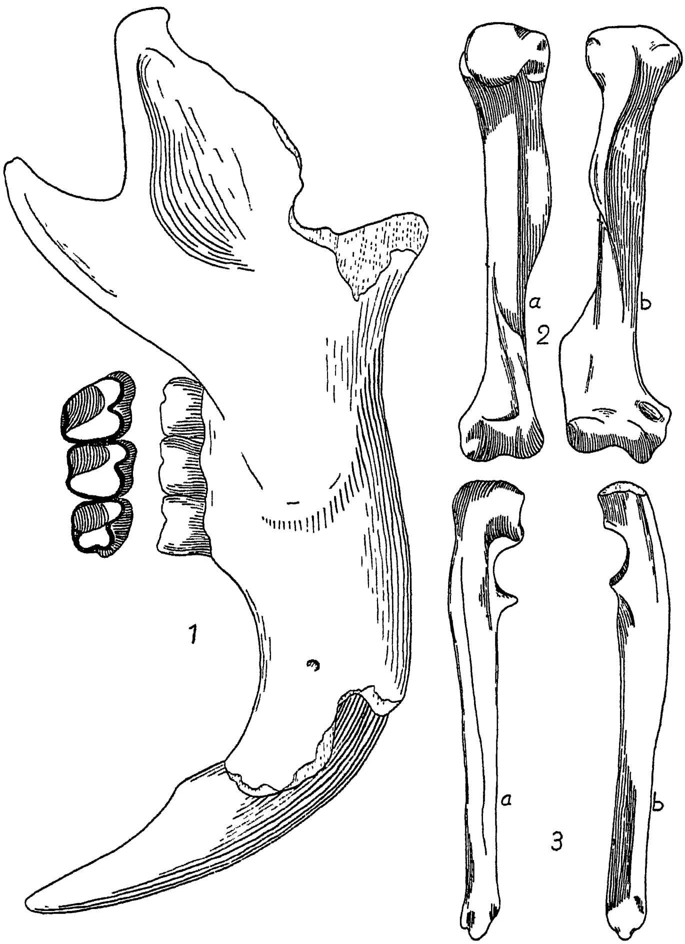
b

the crowns a nearly quadrate appearance though they all have a greater width than their anteroposterior diameter. The metaloph on P^4, M^1 and M^2 is not continuous w:th the protocone, and it is lacking on M^3. The cusp nomenclature is that used by A. H. Howell, pl. 12, 1938. The parastyle ridge on P^4, M^1, M^2 and M^3 rises evenly to join the protocone. The molars have well developed roots.



EXPLANATION OF PLATE II

Fig.

1. *Citellus (Pliocitellus) fricki,* nov. subgen. and sp., holotype No. 24627 F:A.M., lateral view of left ramus and occlusal view of lower molars, three times natural size.

2a-b. Anterior and posterior view of right humerus of holotype of *Citellus (Pliocitellus) fricki,* one and one-half times natural size.

3a-b. S:de views of right ulna of holotype of *Citellus (Pliocitellus) fricki,* one and one-half times natural size. (Drawings by Frances Watson)

The ramus is heavier than that of *C. franklinii* The transverse thickness of the lower incisor is 1.8 mm. The dorsoventral depth of the incisor is 3.3 mm. The diastema is 8.7 mm. The depth of the ramus over the mental foramen is 6.0 mm.; below the middle of P_4, 8.0 mm.; and below the middle of M_3, 7.3 mm.; measured on the lingual side. Length of ramus from tip of incisor to condyle is 39.5 mm. Anteroposterior length of the mandibular tooth row is 10.3 mm. Anteroposterior diameter of P_4-M_2 is 7.4 mm. The mental foramen is situated as in *C. v. grammurus.* The portion of the ramus from the base of M_3 to the tip of the condyle is more strongly developed than in other squirrels of comparable size, the ridge being more rounded in appearance. The mandibular foramen lies on the ridge instead of dorsal to the ridge as in other *Citellus* examined. P_4 lacking a paraconulid. The transverse diameter of P_4, M_1 and M_2 is greater than the anteroposterior diameter. M_1 is rectangularly shaped while M_2 is triangular, the entoconid is crowded toward the paraconid.

Among the skeletal remains are humeri, radii and ulnae. The over-all length of the humerus is 37.6 mm. The over-all length of the radius is 31.8 mm. The over-all length of the ulna is 39.2 mm. They compare in all respects with those of our recent *Citellus.* There is a fragment of a scapula and there are nine fragmentary vertebrae. The calcaneum and tibia are like those of a ground squirrel. The over-all length of the tibia is 49.4 mm. The metacarpals compare in length with those of the ground squirrel of the same size and are not elongated as in *Sciurus* of the same size.

Discussion.—Citellus fricki resembles the Recent *Citellus* in the development of the molar teeth and their patterns being much like those of *C. variegatus grammurus* in the possession of a well developed broad protocone supported by a strong root. On the other hand, the development of the skull, the presence of the ridges on the outer and anterior margins of the zygomatic process of the maxillaries which continues forward on the side of the premaxillaries following the contour of the incisors to the alveolus and the reduced peg-like P^3 are characters in common with the fossil forms, *Citellus (Protospermophilus) quatalensis* Gazin and *C. ridgwayi* Gazin. The size of *Citellus fricki,* the skull characters and the triangular development of M_2 separates it from the following fossil forms, *Citellus ridgwayi, C. quatalensis, C. gidleyi* Merriam, Stock and Moody, *C. bensoni* Gidley and *C. rexroadensis* Hibbard.

No attempt will be made to try to discuss the relationship of *C. fricki* with the other fossil forms. To do this adequately one must be able to compare and study the fossil specimen under discussion. As far as I can tell from a close comparison with the recent forms of *Citellus* it shows no close relationship to any form. It possesses characters common to some of the subgenera, more in common with some than others, but on the other hand, the character of P^3 and M_2 would not allow it to be in the direct line of descent of our recent forms

Fossil Mammal Tracks in Graham County, Kansas[1]

GEORGE M. ROBERTSON and GEORGE F. STERNBERG, Fort Hays Kansas State College, Hays, Kansas

Early in the fall of 1941 I. R. Mort, Postmaster of Hill City, Kansas, reported to us the presence of some mammal tracks in "Cretaceous chalk" on the farm of Oliver Smith in Graham County.* With the kind permission of Mr. Smith, we studied the site and removed some tracks and took casts of others. These specimens are now in the Fort Hays Kansas State College Museum at Hays.

The tracks were exposed by a washout of a pasture pond spillway. (1) A small stream flowing across the exposure kept the area continually wet, which made excavation of the tracks difficult. Freezing and thawing softened the matrix also, eventually making further study of the tracks impossible.

The exposed area was about 150 feet by 20 feet. At the upper end the tracks were especially abundant, many of them over-lapping. Many of the tracks were indefinite in form due to slippage, superposition, etc., but others were definite enough to allow the foot-form to be determined. For the purpose of identification we compared the tracks and casts with the feet of recent and fossil mammals in the Nebraska State University Museum at Lincoln.

The largest tracks are nearly circular (Fig. 1.). Some specimens which showed no indication of enlargement due to slippage or to erosion measured 15 inches or more in diameter. Toe marks are indefinite, as they are on tracks of modern elephants. Our large tracks correspond in form to the outlines of the feet of modern elephants and for that reason we refer them to some mastodon.

Somewhat smaller tracks, about 8 inches in diameter, agree well with those of modern rhinoceros (Fig. 2). They show the three toe imprints plainly.

Artiodactyl tracks of two sizes are fairly abundant. The larger are about six inches in length by five in width (Fig. 3). The smaller are about half that size (Fig. 4). It is possible that the smaller tracks may have been made by some different artiodactyl than the larger tracks, but there is a close enough likeness between them to suggest that they were either tracks of younger individuals or that two different species may have been present. The tracks show two sharp toe impressions, and some modelling of the ridge left by the mud which squeezed up between the toes. The form of the tracks is more nearly like that of camel than any other.

One track (Fig. 5), six by four inches, indicates the presence of good-sized carnivores. This track shows three toe imprints and the marks of three compressed claws. It is deeply imprinted and shows no sign of slippage or distortion. Thus far we have been unable to determine the animal which might have made such a track. Carnivore footbones are not common fossils

[1]Contribution No. 41 from the Department of Zoology of Fort Hays Kansas State College, Hays, Kansas.

*The farm is located in Section 33, Township 7 south, Range 24 west.

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and so seldom are they articulated that we know little of the actual foot-form.

Domestic dogs and cats are somewhat variable in digit number but one hesitates to assign a track to an abnormal foot. The claw marks are definite. Since cats have retractile claws they would not ordinarily show in a track, although it is possible that a cat stepping into mud as deeply as this track indicates might protrude the claws. Scott (2) regards the claws of machaerodonts as imperfectly retractile. *Machaerodus* would thus be a possible maker of the track we found but for the reduction of digits.

The print of a dog's foot in mud is sometimes apparently tridactyl. This seems to be due to the approximation of the two center claws. These two sometimes lie practically in contact, and it is possible that in mud they would squeeze together even more, with a resultant tridactyl print from a tetradactyl foot.

Among the Pliocene carnivores which might have produced a track six by four inches are the canids *Borophagus, Osteoborus,* and *Hyaenognathus,* and the felid *Machaerodus,* although in any case one would be uncertain due to the toe number. Possibly the spring freshets will uncover additional tracks, including additional carnivore imprints.

The rock in which the tracks are imprinted is continuous below with chalk of the Niobrara formation. The chief difference between it and this Cretaceous material is in the proportion of clay mingled with the chalk and the pebbles embedded in the upper part of the track-bearing rock. There is enough clay in the track horizon to permit molding it by hand when it is well soaked. The pick invariably accumulates a coating of sticky yellow clay. Practically all the pebbles are "hard rock" fragments which had been stream-worn before deposition. The sedimentary pebbles thus far seen are of chalky limestone. Since the igneous and metamorphic fragments are not characteristic of any age and the sedimentary fragments came from the Cretaceous bed of the old water-hole the pebbles give us no clue to the age of the tracks.

We regard the tracks tentatively as of Pliocene age, although the evidence is meager. Rhinoceroses range from Eocene to Pleistocene in this country. The size of the tracks indicates an animal of the bulk of the Pliocene *Teleoceros*, but we do not know enough about the foot form of the various genera to regard a track as diagnostic. Camels likewise could have been of other than Pliocene age, although Pliocene forms such as *Pliauchenia* would have been of size sufficient to have left such tracks as we found. Mastodons are found in North America from Miocene to Pleistocene, and any one of a considerable number could have produced tracks of the size and form of those we found. Pliocene genera from this region were *Trilophodon* and *Gnathabelodon.*

The overlying sand thus far has yielded one specimen of *Testudo orthopygia* and one eroded mastodon vertebra. How much younger either may have been than the tracks we do not know. *Testudo orthopygia* is recorded from "Loup Fork", but according to the recent report on Tertiary stratigraphy (3) this term has been applied to beds ranging from Miocene through Pliocene. It is hoped that the age of the overlying deposit can be determined more closely at a later time.

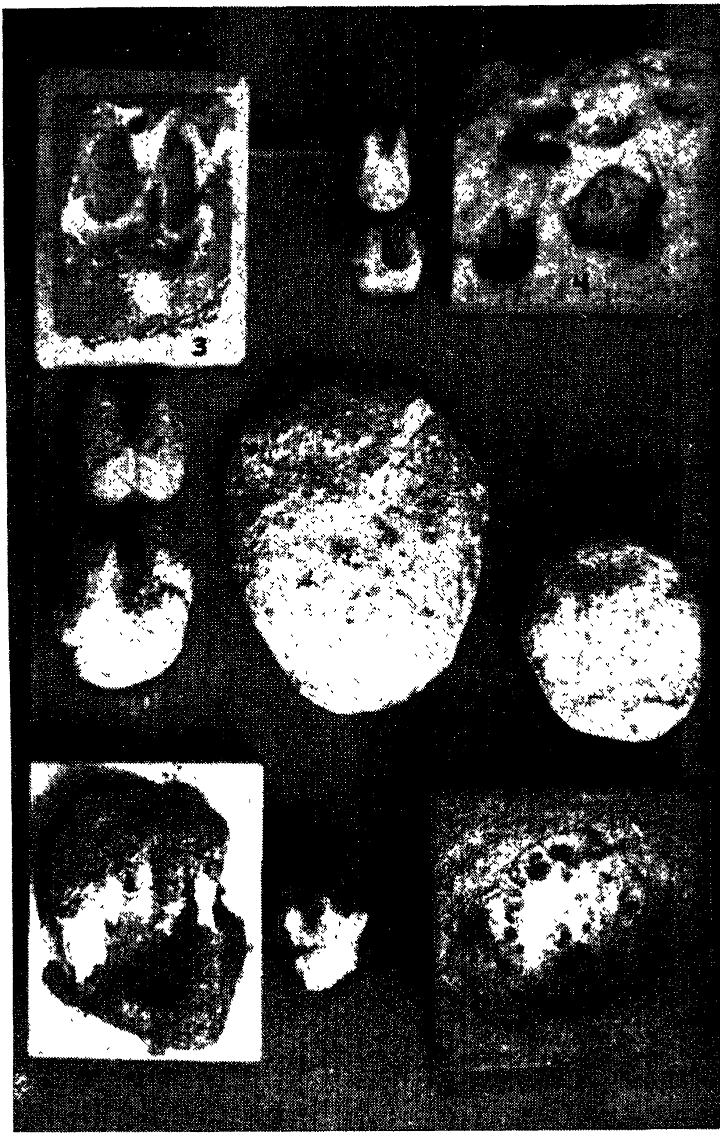
Above the track horizon the mantle is predominantly sand. A detailed section shows the following:

	Feet	Inches
1. Soil probably loessial	2.5-3	
2. "Sub-soil", probably loessial, with considerable caliche and with calcereous concretions extending into the underlying sand	3-4	
3. Sand with some clay and caliche, brown to gray	12	
Poorly defined breaks separate this sand into layers:		
3a. Sand with considerable clay, and pebbles in upper foot ... 2 feet		
3b. Sand ... 4 feet		
3c. Sand ... 6 feet		
This layer rests unconformably on the marly chalk beneath.		
4. Marly chalk with iron streaks, concentric markings, and small clay lenses	0	7-16
This is the track-bearing horizon. The variation in depth appears to be due to differences in depth of erosion. The 7 inch depth represents that in the area from which we excavated most of the tracks.		
5. Greenish clay (Bentonitic?) with some white and yellow streaks	0	2
This bed is quite marked and made a good bedding plane for removal of track-containing blocks.		
6. Gritty chalk	0	6
7. Gritty chalk with considerable clay in streaks and small lenses	0	9
8. Similar to 7	0	7
9. White layer, chalk, or ash with admixture of chalk	0	1
10. Gritty chalk with clay streaks	0	8
11. Clay (Bentonitic?)	0	3
12. Marly chalk	0	7
A fossil of the Cretaceous fish *Empo* was found in this layer (1).		
13. Clay	0	2

Our interpretation is that some time during the Tertiary, probably Pliocene, the Cretaceous chalk was exposed, and in a water-hole was mingled with sufficient clay to make it muddy. In the mud of this water-hole were impressed the tracks of various creatures which made use of it. Sand filled in over the mud, preserving the tracks until recently, when erosion due to the washing out of the pond spillway cut down to that level, once more exposing it. Each year for the past three seasons additional tracks have been exposed as the erosion has removed more of the over-burden, and each winter those previously exposed have largely disintegrated due to frost action.

REFERENCES

1. Sternberg, G. F., and Robertson, G M. A Pliocene water-hole in Western Kansas, Science, Vol. 94, No. 2456, p. 97, Jan. 23, 1942.
2. Scott, W. B. A History of Land Mammals in the western hemisphere, Rev. Edit. Macmillan, 1937, p. 612.
3. Wood, H. E., edit. Nomenclature and correlation of the North American Continental Tertiary. Bulletin Geol. Soc. Amer. 52, p. 24, 1941.



FOSSIL MAMMAL TRACKS

Fig.
1. Cast of Mastodon track.
2. Rhinoceros track and cast of another.
3. Camel track and casts of two others.
4. Tracks of small camels (?) and casts of two others.
5. Carnivore track and cast of same.

All figures x 1/8th.

29
Kansas Amber

WALTER H. SCHOEWE, University of Kansas, Lawrence, Kansas

Amber is a fossil tree gum or fossil resin derived from coniferous trees. It is a non-crystalline hydrocarbon composed of resins, oil and succinic acid; the latter substance being responsible for the mineralogical name succinite which is sometimes applied to amber. The Kansas amber is light butterscotch in color or some other shade of brown. It is waxy, shines as if polished, is cloudy to translucent, and is made up of more or less concentric bands somewhat like agate. The amber has a hardness of about 3, that is it can be scratched very easily with a knife. Some individuals may be able to scratch it with their fingernails. It is brittle and breaks with a conchoidal or shell-like fracture. It will flake or chip just as flint does when making an arrowhead. The amber is not only light in color, but it is also light in weight. Its specific gravity is just a little over 1, or slightly denser than water. Chemical tests by Buddhue (1938) show that the Kansas amber has a brilliant bluish green fluorescence in ultraviolet light and when heated emits a strong resinous odor, burning readily with a long smoky flame. It is about 38 per cent soluble in cold chloroform.

The Kansas amber is found in Ellsworth County along the banks of the Smoky Hill river about 5 miles south of Carneiro in sec. 18, T. 16 S., R. 6 W.* The amber occurs in pockets in a shale about three to four feet above the river level. The amber is in the form of irregular lumps from the size of a pea to pieces that measure more than 4x4x2 inches. Associated with it is peat, or coal, decayed and fossilized wood, pyrite or fool's gold, gypsum crystals and gravel. According to Beck, to whom samples of the associated wood were sent by Buddhue (1938 b) for identification, the wood is related to the petrified trees of Arizona. The wood belongs to the *Araucaria* which flourished during the Mesozoic era in North America. The shale in which the amber is found is of Cretaceous age, therefore making the amber at least 60,000,000 years old.

The Kansas amber referred to above was discovered by Mr. George Jelinek of Ellsworth, Kansas, either in 1937 or January, 1938. Originally it was named Kansasite by Buddhue (1938 a) and later renamed by the same investigator (1938 b) jelenite in honor of Mr. Jelinek, the original discoverer of the amber. I wish to thank Mr. Donald Staver for first calling my attention to Kansas amber, for the fine specimen he gave me and for information relative to its occurrence.

LITERATURE CITED

BUDDHUE, JOHN DAVIS, 1938a, Some new carbon minerals—Kansasite described: The Mineralogist, vol. 6, no. 1, pp. 7-8.

———, 1938b, Jellinite and associated minerals: The Mineralogist, vol. 6. no. 6, no. 9, pp. 9-10.

*Professor D. C. Schaffner of the College of Emporia recently reported the finding of small amber fragments about 3 miles southeast of Elkader in southeastern Logan County.

30

Notes on the Evaporation of Thin Metallic Films

DAVID M. GATES, University of Michigan, Ann Arbor, Michigan

Most of the common metals can be vaporized from the liquid state, except a few, such as arsenic and chromium, which sublime first. Evaporation, as practiced in this laboratory, is conducted inside a bell jar evacuated to 10^{-3} centimeters of mercury or better. The solid metal is placed in a vertical 20 mil tungsten coil as described by Strong (1) and heated by passing a current thru it. When the temperature is sufficiently high the solid will melt, fill out the coil, and begin to flow over the surface of the tungsten. The interfacial reactions between the liquid metal and the coil is of utmost importance in evaporation. The greater the attraction of the liquid molecules for one another, the greater is the surface tension and the less the degree of wetting. The temperature of the coil must therefore be made higher to give sufficient energy to the metal to cause evaporation of an atom or a molecule from the surface. If a high degree of wetting of the coil is obtained, then evaporation takes place readily and evenly; but on the other hand, where the degree of wetting is small, one is likely to have large particles of the metal shot out and splashed on the surface to be coated. The solubility of the coil in the evaporating metal and the melting point of the coil are additional properties to be considered when choosing the coil (2). A spectroscopic determination showed that none of the tungsten coil was evaporated in gold and silver deposits.

Arsenic is one of the few metals which sublimes before melting and because of this fact it does not wet the filament. Chemically pure granulated arsenic was used for these experiments. When heated in the tungsten coil most of the metal jumped out, only a small amount depositing. A small quartz crucible was made which fitted into the tungsten coil and the arsenic was placed in this. A cover for the crucible was constructed from fine nickel screen cut from the outer screen grid of a 6C5G radio tube. The perforations of this screen were sufficiently small to retain the granulated arsenic yet allowed the metal to evaporate evenly thru the screen. To obtain emission in all directions the crucible was constructed entirely of the metal screen and the crucible placed in the tungsten coil. The arsenic deposited as a very shiny brown film and adhered very tenaciously to glass.

To determine the eveness of evaporated silver layers on chemically clean glass, microphotometer curves were obtained. The readings of the microphotometer were practically linear for very thin films. The microphotometer beam was run across the plate in several directions before and after evaporation to eliminate any irregularities due to the glass. Evaporation was conducted from molybdenum coils since the metal appeared to wet this metal better than tungsten, thus giving a slightly smoother evaporation. Four molybdenum coils with equal amounts of silver in each coil were placed ninety degrees apart and just above and outside the periphery of a circular piece of glass. This arrangement gave a deposit which decreased slightly in thickness

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towards the center, but the variation in thickness was not sufficient to cause trouble on mirrors with a diameter less than 12 centimeters. Almost perfect uniformity was obtained from six coils placed sixty degrees apart with equal amounts of silver in each coil. In general, it was found that evaporation should be conducted at the lowest possible temperature to assure uniformity of the deposit. The ideal condition exists when the ratio of heat radiation to molecular radiation is a minimum.

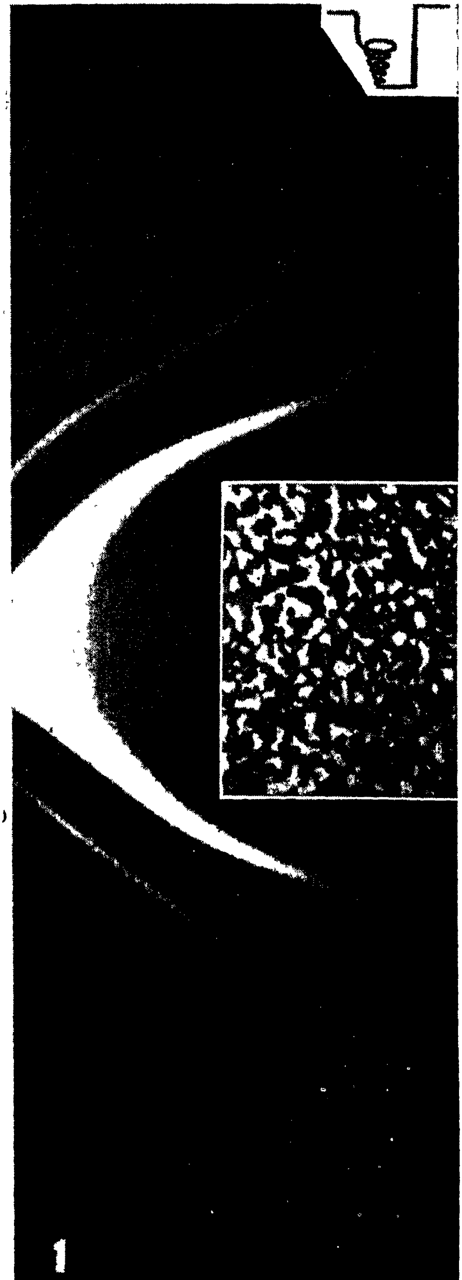
When bismuth is evaporated at a pressure of .4 mm of mercury in air it deposits as an intensely black layer (3). This process affords an easy method for blackening thermocouple receivers. When the metal melts at this pressure it produces an oxide crust upon the surface which impedes evaporation unless the temperature is quickly increased to break this potential barrier. The particle size of bismuth black, as observed with the electron microscope, varied from 300 to 500 angstroms depending upon the distance from the coil and the rate of evaporation. At a given pressure the rate of evaporation will change the size of the particles obtained in the deposit.

To determine what caused the metal to come down as a black deposit when evaporated in air at a pressure of .4 mm of mercury, evaporation was conducted in oxygen and in nitrogen separately. In oxygen, an intense black deposit was obtained at a pressure of 2 mm, a gray one at 8 mm, a light blue deposit at 6 mm, a yellow deposit just below 6 mm, and a white deposit above 7 mm. Evaporation in nitrogen at a pressure of .4 mm gave a very good mirror surface which continues until the pressure rises to about 3 millimeters. The deposit then becomes dirty in appearance; when the pressure rises as high as 6 to 10 millimeters of mercury, the deposit in nitrogen is intensely black. In air, the black deposit covered all surfaces within the bell jar; while in nitrogen a very interesting phenomenon was observed. The region of deposition consisted of a double spiral pattern on the side of the bell jar and a continuation of this pattern on the base beneath the coil (Fig. 1). This spiral was perfectly symmetrical and no deposit occurred outside of it. The spiral occurred at all pressures in nitrogen where a black deposit was formed.

Attempts to determine the cause of the spiral deposit have been made, but no conclusive results have been reached. A horizontal coil mounted in the same manner as the vertical coil gave exactly the same pattern. By mounting the coil in a different manner, so that the electric and magnetic fields existing between the leads were changed, a different pattern was obtained. This difference indicates very strongly that we are dealing with charged particles which are being directed by an electric or magnetic field. More investigations are to be made into these effects.

I have evaporated sodium chloride, potassium chloride, potassium bromide, lithium fluoride, and sodium fluoride because of their importance as prisms and windows in spectroscopy. Sodium chloride, potassium bromide, and potassium chloride deposit as very milky, but tenacious films, whereas lithium fluoride and sodium fluoride deposit as very clear films. The degree of cloudiness of the evaporated layers of the same thickness is proportional to the hygroscopic properties of the compound. The cloudiness exists when the film is in the high vacuum and does not change visually as air is let in, but one's breath does change it appreciably.

Bottom Top



EXPLANATION
OF FIGURES

Fig.

1. Bismuth evaporated in nitrogen at a pressure of 8 mm from a tungsten coil of the shape shown on the insert in the upper right-hand corner.
2. Electron microscope photograph of potassium bromide evaporated onto cellulose film. Magnification 8000 times. 1 mm equals approx. .125 μ.

A thin layer of lithium fluoride evaporated onto sodium chloride or potassium bromide gives a very good protecting surface against atmospheric moisture. In the infra-red region from 15 μ to 1 μ the protective surface decreases the intensity of the beam very slightly but gives no absorption bands The thickness of the highly transparent films can be obtained by observing the interference fringes which arise from the two surfaces. The layers used were from 3 to 4 $\times$ 10^{-6} centimeters thick and hold up very well.

The electron microscope shows that the evaporation of pure metals takes place as molecular radiation but indicates that such compounds as potassium bromide and potassium chloride evaporate in small globules with diameters of about ⅛ to ¼ μ and that these are not entirely crystalline (Fig. 2). An attempt will be made to determine the difference between the layers which come down as white, turbid deposits and those which are clear.

For suggestions and for the use of the apparatus, I wish to express my appreciation to Dr. Ernest F. Barker and other members of the Department of Physics.

REFERENCES

1. STRONG, JOHN. Procedures in Experimental Physics, p. 176.
2. JOURNAL OF APPLIED PHYSICS, 12, 779, 1941.
3. REVIEW OF SCIENTIFIC INSTRUMENTS, 1, 397, 1930.

31

An A. C. Arc as a Spectroscopic Source

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Prior to the development of the low-frequency, high-potential arc the common excitation sources for spectroscopic analysis were the flame, the spark, and the low-potential arc. The flame was originally used by Bunsen in 1859, and it is employed principally in identifying the metals of the alkali and alkaline earth groups. The spark method was first reported by Hartley in 1882. This excitation method makes a certain amount of noise and usually shows air lines, but uses so little of the sample that the illumination is fairly constant during its operation. The low-potential arc was discovered by Davy in 1808, thus being the oldest method known. The arc moves about on the ends of its electrodes, rapidly consumes the sample, and gives a relatively irregular performance during its operation.

Some of the above inconveniences have been removed in one of the newer forms of excitation—the low-frequency, high-potential arc. Experiments with this device have been reported at the University of Michigan (1), the laboratories of the Bell Telephone Company (2), and the Dow Chemical Company (3). The purpose of the investigation reported here was to devise a method for keeping the performance of this type arc constant and also to find a method for suppressing the air lines and bands.

The source used in this investigation was a 7.5-KVA, 60-cycle, hi-reactance transformer. The secondary voltage was 10,000 volts on open circuit. Two ¼-in. aluminum rods were used as electrodes. It was noted that the arc wandered irregularly over the ends of the rods and that the arc carried up past the end of the top electrode as the gap betwen the rods was increased. To decrease the wandering, a ¼-in. copper tube was substituted for the upper electrode and a vacuum system was attached so as to draw the arc into the end of the tube. When the preceding tests were repeated while the air was being drawn into the copper tube, the arc held its position and ceased its wandering. Use of the air current caused the arc to be constant in position and in illumination so that a constant optical density on spectroscopic negatives was achieved. Photographs of the arc with and without the pump in operation are shown in Fig. 2A and 2B.

In the arc or spark current must pass from one electrode to the other This current is carried by ions and electrons. At the center of an arc many of these ions are supplied by the air so that the lines and bands of the air spectrum appear in many spectrograms, and their presence masks out or makes useless to the investigator a large part of the spectrum. It occurred to us that these air lines and bands could be eliminated if other ions were introduced into the arc to take the place of the air ions. To introduce into the arc ions from some easily volatilized substance, a third heater-electrode was constructed. This device is shown in Fig. 1. A cigar lighter made of nichrome wire was

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used as the heater, and in order to prevent the sample coming into contact with it, a platinum cup was constructed as a retainer for the sample. The dish and heater was surrounded by a brass ring having a hole bored through one side to take ¼-in. copper tubing. Water circulating through the tube prevented the ring from getting too hot. To the top of the brass ring was mounted an aluminum cone with a small opening at the vertex. A photograph of the heater-electrode is shown in Fig. 3A and 3B.

The apparatus was operated with alkali salts in the platinum dish. After several salts had been tested, a sample of potassium nitrate (KNO_3) was found to fuse readily and, when heated sufficiently high, to produce a steady stream of vapor. The apparatus was placed in position in front of a Bausch and Lomb medium quartz spectrograph and a series of spectrograms was taken. A metal screen was placed between the spectrograph slit and the arc, allowing only the central portion of the arc to record on the plate. As the upper end of the arc was the copper tube and the lower end the aluminum cone, the arc showed the persistent lines of these metals and the air bands. The sample of potassium nitrate introduced the persistent lines of potassium and also those of sodium. These can be seen in Fig. 4. The first exposure shows the lines of the normal arc, aluminum, copper, and air bands. The second exposure was made a few minutes later while the hot stream of ions from the potassium nitrate had changed the character of the arc. We see that the former spectrum has been entirely replaced by the potassium and sodium lines.

Later a series of spectrograms of the arc was taken to discover if there were any differences at different positions in the arc. The arc was about 15 mm. long. These spectra are shown in Fig. 5. The bottom exposure in each pair shows the normal arc and the top one shows the result with the heater operating. At the aluminum end the spot of light which always accompanies these discharges and which stays close to the electrode was in view, so that the spectrum for this position is partly a continuous spectrum. Otherwise the effect of the heater on the arc was about the same at all points in the arc.

In this investigation we have shown that an arc may be stabilized by a current of air being drawn into the top electrode. We have also shown that a stream of ionized vapor passed through the arc will suppress the air lines and bands. Unfortunately, the lines belonging to the normal spectrum of the copper and aluminum electrodes were also so nearly suppressed that the resulting spectrogram was of little use as a means of studying the lines of the electrodes. Since the ionization potential of potassium is so much lower than that of the metal electrodes, the other metals seem to be entirely replaced If it were possible to find an ion carrier that did not have as low an ionization potential as potassium but still lower than that of oxygen and nitrogen, the air lines and bands might be appreciably masked and still leave a high enough potential difference across the arc to excite the lines of a specimen.

LITERATURE CITED

1. DUFFENDACK, O. S., WILEY, F. H., and OWENS, J. S. Quantitative analysis of solutions by spectroscopic means. Indus. and Eng. Chem., Analyt. Ed. 7:410-413. 1935.
2. JAYCOX, E. K., and RUEHLE, A. E. Qualitat've spectrochemical analysis of alloys, solutions, and powders. Seventh Summer Conf. on Spectroscopy, Proc. New York. John Wiley, 154 p. 1940.
3. HESS, T. M., OWENS, J. S., and REINHARDT, L. G. Analysis of organic materials for traces of metallic impurities. Seventh Summer Conf. on Spectroscopy, Proc. New York. John Wiley, 154 p. 1940.

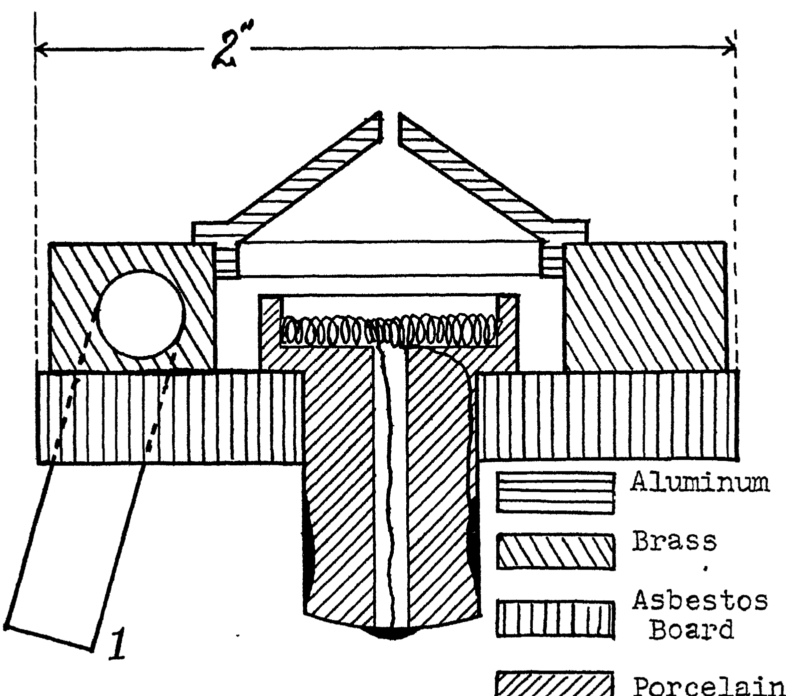
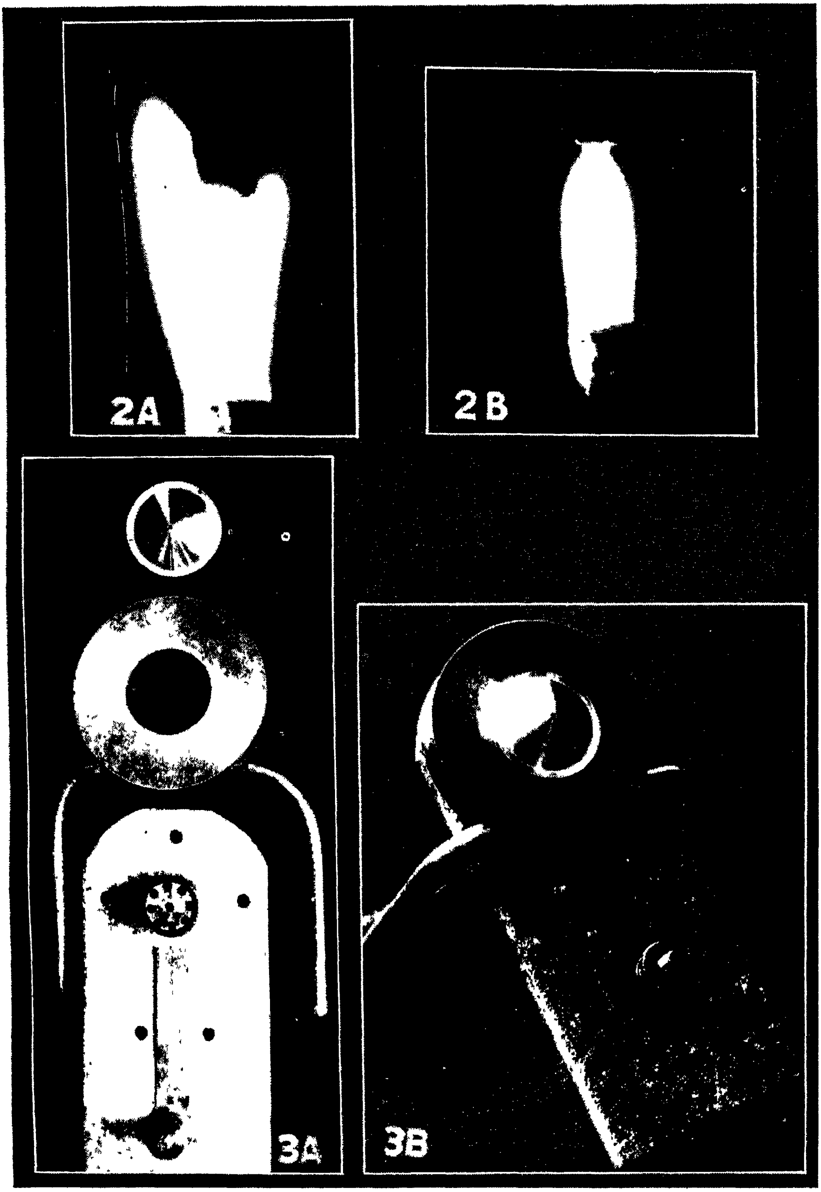


FIGURE 1. Diagram of heater-electrode.



FIGURES 2A and 2B. Photograph on the left (2A) without vacuum pump in operation; on the right (2B) with vacuum pump in operation.

FIGURE 3A and 3B. Photographs of heater-electrode. Left hand picture (3A) is top view unassembled; right hand picture (3B) is top view assembled.

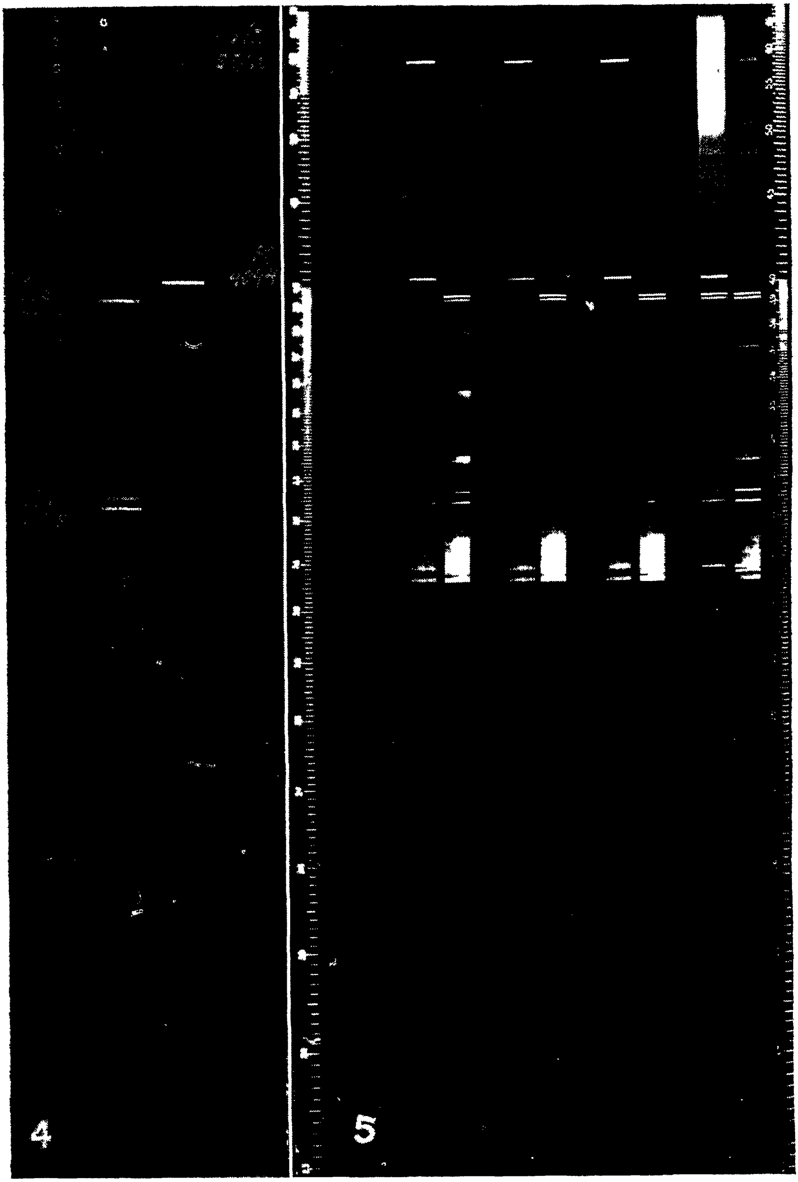


FIGURE 4. Upper spectrogram without and lower spectrogram with heater in operation.

FIGURE 5. Spectrograms taken at various positions along arc. The bottom of each pair is taken with heater off; top, with it on. Bottom pair is taken near heater-electrode, top pair near copper electrode.

The Thurstone Vocational Interest Schedule and Students' Actual Vocational Choices

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The purpose of this investigation was to discover the amount of agreement between college students' expressed choices of vocation and their scores on the Thurstone Vocational Interest Schedule.

The subjects consisted of 204 freshmen entering Fort Hays Kansas State College in the fall of 1938. These students were first given information blanks on which they were asked to indicate three choices of vocation—their first choice of vocation immediately after finishing school, their second choice immediately after finishing school, and their permanent choice—the occupation in which they wished to be engaged fifteen years hence. They were then given the Thurstone Vocational Interest Schedule, from which seven scores for each student is derived, each score representing a broad field of vocational interest. These seven scores were then ranked in order for each student. Rank Seven represents the highest score, or the field in which the student's vocational interest was supposedly highest, and Rank One represents the lowest score or the field in which the student had least interest.

A check was then made to discover to what degree the students' highest scores on the Schedule, supposedly representing the highest vocational interest, agreed with the choices actually expressed by the students.

Table I shows the percentages of first choices falling into each of the seven score ranks. Rank Zero indicates those expressed first choices which fell entirely outside the scope of the Thurstone Test, i e., those occupations which could be classed under none of the seven Thurstone fields of interest.

TABLE I—Percentage of First Choices Falling in Each Thurstone Interest Rank

Interest Rank	Boys (percentage)	Girls (percentage)
7	28	16
6	18	12
5	10	19
4	12	16
3	12	18
2	12	9
1	7	8
0	1	2
	N=94	N=110
Ave. Inter. Rank	4.7	4.2

Table I indicates that only 28% of the boys' first choices and only 16% of the girls' first choices actually fell in Rank Seven. In other words, the percentage of cases in which the students' first choice *disagreed* with the highest ranking Thurstone interest was 72% for boys and 84% for girls.

The same disagreement between expressed choices and Thurstone scores is evident in the permanent "fifteen years hence" choice (Table II).

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TABLE II—Percentage of Permanent Choices Falling in Each Thurstone Interest Rank

Interest Rank	Boys (percentage)	Girls (percentage)
7	35	18
6	17	7
5	8	11
4	11	9
3	11	11
2	10	2
1	6	2
0	2	40
	N=94	N=110
Ave. Inter. Rank	4.9	2 9

The failure of the test to indicate permanent interest of girls is very evident. Forty percent of girls' permanent choices fell entirely outside the Thurstone fields of interest. An analysis of each girl's expressed permanent choice was made, which indicated that about half of this 40% was comprised of girls who chose marriage as permanent careers. Doubtless the failure to take this factor into account is one of the greatest of Thurstone's oversights, a mistake which seems to indicate that the Thurstone Schedule is a boys' test. Going one step more, one can hardly refrain from estimating how many more than 20% of freshmen girls will ultimately forsake their immediate career choices and make marriage their permanent occupation.

Closer agreement between girls' second choice of occupation and their Thurstone scores is indicated in the average interest ranks in Table III.

TABLE III—Percentage of Second Choices Falling in Each Thurstone Interest Rank

Interest Rank	Boys (percentage)	Girls (percentage)
7	28	15
6	24	15
5	11	20
4	10	15
3	4	13
2	6	7
1	10	5
0	7	10
	N=94	N=110
Ave. Inter. Rank	4 7	4.1

The average interest rank for second choices again indicates that the test scores agree more closely with the actual choices for boys than for girls. In addition to this, in each of the tables, if the chance factor is considered, the difference between the chance percent of 14% and the actual percent of cases in the upper ranks is much more favorable for boys than for girls. For instance, in Table III, in Rank Seven, the percent for boys is 14% above chance to 1% above chance for girls.

The lack of agreement between Thurstone scores and students' expressed choices of vocation raises one question. Did the students answer more accurately in expressed choices or in the Thurstone Schedule? Our answer is that since asking students to record a choice of vocation involves a more direct method of questioning than the method used in the Thurstone Schedule, the expressed choice is to be considered the more accurate response on the part of the student.

By way of summary, it was found that there is little significant agreement between the highest ranking Thurstone scores and expressed vocational choices of students, the average agreement being 23%, only 9% above chance. The amount of agreement is higher for immediate temporary choices than for permanent choices, and is higher for boys than for girls. We conclude that the Thurstone Vocational Interest Schedule is of little value in vocational guidance, and that we can get more reliable information in less time by individual conferences with students

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Mutual Participation in Adjustment Techniques as a Factor in Problems Involving Present Human Relationships

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The adjustment technique described herein is predicated on two premises: first, that all behavior is expressive of personality and therefore we need not seek significant episodes in developing insight into adjustment problems but may assume that any episode if carefully studied will yield full significance for personality problems; second, that adjustment techniques which are carried on only through contacts between the adjustor and the adjustee are satisfactory only when the adjustee's problems involve merely memories. If the adjustee is unsatisfactorily adjusted in his relationship to some individual with whom he must participate in a living, changing, developing relationship which will necessarily be affected by the personality of the opposing character in this relationship, then no satisfactory adjustment can be reached unless both individuals concerned share in every phase of its development.

Techniques which consist primarily of effecting a change of attitude on the part of one person, involved in a dual problem, or of effecting change of attitudes through separate contacts with each person, or of granting to the adjustor the role of intermediary and elucidator have all left much to be desired from the standpoint of developing permanently reliable relationships. By far the most satisfactory results from the techniques which involve interview procedure participated in by the adjustor and adjustee alone have eventuated when the only adjustment required was a tolerant understanding of remembered episodes and personalities which were not part of the present or future life of the adjustee.

The effort to discover a technique which would be satisfactory for the development of adjustment to present dynamic relationships resulted in experiments with mutual play therapy. In this technique the play therapy is always participated in by three people, the adjustor, and the two persons who are not enjoying satisfactory relationships with each other but who must have significant contacts. Neither of these two latter people is ever seen alone by the adjustor. They are always seen together for the entire period of interview and throughout the period of adjustment. Whatever interpreting takes place is carried on with full cognizance of both persons involved. This has proved of great assistance in establishing confidence in the adjustor on the part of both subjects.

The play method is used as a dramatization of events and provides objectivity to all participants. Each subject is asked in turn to select some episode in which he feels he has been misunderstood or mistreated by the other subject. He is left free to choose his own episode and is assured that trivial episodes are as useful as any. The use of episodes which seem trivial and of slight portent to the subject leaves him more free to dramatize the incident

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frankly without embarrassment and therefore presents a more advantageous expression and interpretation of personality.

When subject A has selected an episode, he dramatizes it with the play material. He takes his own part and subject B carries the part he himself took in the genuine circumstance. If other characters are needed, they are supported by the adjustor with sufficient instruction from the subjects to produce tolerable verisimilitude. During the first dramatization subject A, who has chosen the episode, is urged to speak his thoughts aloud as they occurred to him at the time of the incident as well as to reproduce his actions and words of that time. Comment or discussion of the episode is not included during this dramatization.

After subject A has completed his dramatization, it is repeated in the same manner except that this time subject B is the one to express his thoughts aloud as they had occurred to him at the time the experience took place. During this second dramatization A merely goes through his part repeating the overt behavior of the episode as B had done during the first dramatization.

After these two dramatizations there is discussion of the episode. The adjustor does not take the lead but approximates the function of the Greek chorus and translates into generalized psychological meaning the aspects of the situation which still remain confusing to the subjects. When the episode has been mutually clarified to the satisfaction of all concerned, including the adjustor, the episode is again dramatized twice. This time A revises his part and has his puppet act and speak as A would do if he could actually re-live the incident with the benefit of the information and understanding of B's part which he now possesses. The last dramatization is a similar revision of his part by B. Sometimes this final dramatization stimulates a little further discussion.

Skill in interpretative interviewing is assumed as part of the adjustor's equipment and such skill will keep the procedure from deteriorating into argument or recrimination. The subjects are always aware that elucidation of personality is the objective of the procedure. All are interested in the episode only as an index of personality traits which must be accepted if an adjusted relationship is to develop.

One complete handling of an episode constitutes a period. Successive periods are used until the development of a new relationship between the subjects which progresses through the periods has reached a satisfactory point where it appears that it will now continue to develop with increasing satisfaction to both subjects.

Sometimes it becomes apparent during the first few periods that there is good reason for the adjustor to suggest that a definite progression either in time or logical relationship be followed in the selection of episodes for dramatization. In other cases it seems best to leave the subjects entirely free in this matter of choice because the choice of episode is following the actual line of development of the new relationship. The results which one may expect with such technique are exemplified in the following three different types of disturbing situations in which it was used.

1. A couple had adopted two children, at different times. The first child was a boy and had reached the age of thirteen with consistent satisfaction to both parents and apparently to himself. The second child, a girl, was two

years younger and had been taken at the age of eighteen months. She had never been a source of satisfaction to her parents or herself, was a disciplinary problem in school, had difficulty in ordinary social contacts, was of a highly negativistic disposition, and had developed serious symptoms of maladjustment, such as using the rug in her bedroom for toilet purposes and unnecessarily and apparently deliberately soiling her clothes.

Examination indicated that the seat of the trouble lay in the mutually unsatisfactory relationship between mother and daughter and mutual play therapy was instituted. With surprising speed the therapy revealed the fact that the child had been so mistreated by her own mother while waiting for adoption from the maternity home that the natural overtures of the adoptive mother, when the child was first taken into the adoptive home, aroused fright behavior which was misinterpreted by the adoptive mother as dislike and which in turn aroused suspicion and antagonism in the mother. The resulting attitude on the part of the mother did nothing to help overcome the repulsive behavior of the child. Meantime, under all the suffering and turmoil these two were causing for each other, had been growing a genuine and strong affection. By the time each became as it were visible in her entirety to the other, a new, satisfying relationship had already developed and beyond the establishment within the child of some tolerant insight into the problems of the natural mother and some release of remanant hostility in this direction, there was little more for the adjustor to do. With the disappearance of the malignant factors from this mother-daughter relationship, the disturbing symptoms at home and abroad also disappeared. Nine months have elapsed since the close of the adjustment period, and the parents continue to report increasingly satisfactory relationships within the family.

2. Case 2 is that of a married couple with three children. The parents were on the verge of separation when they came for help. Apparently the only constructive factor in the entire situation was the desire of both parents to do their best for the children. This best did not include, in their thinking, any possibility of carrying on a life together.

Preliminary, exploratory interviews indicated that the children were all showing increasing symptoms of maladjustment which would probably become deepseated and irremediable if the home were definitely broken. It also became apparent that although these people were not enjoying each other they were still vital to each other. The adjustor pointed out to them in a joint interview that their mutual strong interest in the children and the need of the children for contact with both parents necessitated their continuing some contact with each other throughout the future which in turn meant that they were doomed to share a future relationship, even though they might divorce and both re-marry; that in these circumstances it would be advantageous for them as well as for the children if this relationship could be as comfortable as possible and toward that end it would be well to discover some basis for a comfortable relationship; that mutual play technique offered a possibility for such discovery. They agreed to make the attempt for the sake of comfort in their future contacts through the children. Four rather long evenings went into this effort Again with surprising speed the technique revealed three diversities of personality make-up that were so basic

and so opposed that the ensuing confusion with regard to motives, goals, and attitudes had been inevitable and devastatingly destructive of cooperation and harmonious relationship.

While going through the process of recognizing some basic traits as fundamental differences in mode of thought and feeling and differentiating them from the motives and goals mistakenly assigned by each to the other, the genuine need of these two people for each other fell into its proper place in their thinking and began to serve as the pivotal point for the development of a new relationship which might prove sufficiently satisfying to achieve permanence. They do not know yet whether or not they will remain together, but, whether they do or not, they will probably have a permanently comfortable relationship which may suffice under any circumstances to offer security to their three children and enable them to develop wholesomely.

3. Case 3 was that of a child of eight who had been adopted from an orphanage at the age of nineteen months, after a turbulent infancy, and taken into the home of a young, happy and congenial couple. In this instance it was the father who was especially fond of children and who was the companion and chum of the child. At the age of thirty-six months she lost this adoptive father through sudden illness and death. The mother, who has not yet ceased to grieve, had to take employment to support herself and the child and left her in the care of the adoptive grandmother, a sulky, immature, old lady who could not be tolerated in the homes of any of her own children. Eventually Mrs. X made arrangements for her own mother to leave her home but as this left her without anyone to care for the child it seemed to her the child's best interest could be served by placing her in a boarding school. By Christmas time this child of eight had succeeded in getting herself expelled from the school, and the head of the school had assured the mother that the child was an incurable cleptomaniac, that her condition could be accounted for only by heredity, and that the only solution of the problem was to place her in a custodial institution. When the mother came for help she was, herself *in extremis* of emotional stress, and the child was almost maniacal in the degree of nervous tension she displayed. Immediate play therapy reduced the tension for both mother and child and, later, mutual dramatization was carried on. It became apparent, very early, that this child was suffering from a succession of traumatic experiences and that there had never been a satisfying relationship between mother and child. For that reason this was a case in which a directed series of incidents was used. The mother and child chose the specific incidents which they dramatized, but they were asked to choose from certain periods in the life of the child. During this procedure adjustment was reached in turn: to the child's babyhood, institutionalizing and adoption; to the death of the foster father and to the phenomenon of death in general; to the working life of the mother; to the ill-advised and unsuitable care given the child by the grandmother; to the friendship of the mother for a recent suitor; and finally to the situation which had developed at the boarding school. Before the end of the therapy a great deal of hostility was eventually released by the child and by means of the mutual phase of the therapy the mother had become so adjusted to the child's needs and their manifestation that when this period of hostility release was reached she not only was neither shocked nor disturbed by it but expected it and encouraged

the child even in the release of hostility toward the mother puppet. Such a wholesome relationship had developed between the mother and child by the time this final release of hostility to the mother was achieved that the period of release was short, its expression mitigated by cordial expressions toward the actual mother and the reconstruction period reached with remarkable speed. The child's nervous tension subsided completely, her behavior at home and at public school became wholesome, constructive and socially acceptable and now the mother and child are keeping house together on a satisfying cooperative basis with a sound substratum of mutual affectional security.

Further Studies of the Use of the Galvanic Skin Response as a Deception Indicator

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The use of the galvanic skin response as a deception indicator has been much discredited by the belief that the response fails as a successful deception indicator because of its extreme sensitivity to external and internal stimuli, and because of its occurrence in most emotional situations. Since any investigation of deception usually results in some emotional response on the part of the subject, the G.S.R. is thus thought to be ineffective as a valid indicator of deception. Poffenberger (6) contends that the "Psychogalvanic Reflex Test" is made useless because of the effusion of "cold sweat" by both the guilty and the innocent.

> "...innocence plus being accused will cause cold sweat. Surely anyone's experience will show him that cold sweat is not always due to guilt, although that will cause it. In the laboratory, the test will work often because the conditions are such there is no cause for excitement except the guilt, but in practical life the conditions are not favorable."

Larson (4:237) claims that he obtained better and more decisive results in actual criminal investigations than in the laboratory with continuous blood pressure records of deception. It should be remembered that both blood pressure changes and the G.S.R. are functions of the autonomic nervous system. Marston (5) in describing types of deception tests in his *Studies of Testimony* says that the so-called "galvanometer test"

> "...is of very little value in detecting deception, because the instrument registers nearly every emotion experienced during the testimony of the subject and so renders it nearly impossible to distinguish those emotions caused by deception."

The published evidence for these several conclusions could not be found.

PURPOSE

The purpose of this study is to observe the effect of "fear and intimidation" upon the galvanic skin response in the detection of deception. No attempt is made to validate the G.S.R. as a deception indicator in actual criminal cases; the investigation is limited to controlled laboratory situations.

METHOD AND PROCEDURE

The method consisted in establishing a deception situation wherein a deceit consciousness was induced in the subjects. Appropriate stimuli were used to disturb the consciousness of deception. Galvanic skin response measurements in millimeters of galvanometer deflection were made for each response to the stimuli. The playing-card situation was used; each subject selected one of five cards, mentally concealed his selection, and denied the same. The card situation was used because it provided close control and concentrated the purpose and attention of both the subject and experimenter, a necessary condition for the success of all deception tests. The study was divided into two

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parts, Experiments A and C, control and experimental conditions respectively. In both experiments the nascent G.S.R. was used; that is, the response was not fatigue-adapted through continued excitation over a period longer than 15 minutes, nor adapted to a specific stimulus, as was intentionally induced in Experiment B of the previously reported study (2).

Fifty subjects served for each experiment, some of them serving under both conditions. They are all identified by numbers and are all undergraduates. The technique and apparatus used to measure the G.S.R. have been described (2, 3).

The following procedure was followed in both conditions. The subject was seated in a comfortable chair. The arms of the chair held the liquid finger electrodes in which the subject immersed the index finger of each hand. The subject was installed in the circuit. Preliminary adjustments of the galvanometer were made. Verbal instructions were then presented. Five playing cards—2-Hearts, Ace-Diamonds, 10-Spades, 3-Clubs, and 4-Spades—were then exposed on the desk shelf near the subject. The subject, viewing the cards through a mirror at his left side, selected one and mentally concealed it. The experimenter then presented, one at a time, a number of conditioning cards to ease the discomfort of the subject and to take the unusualness out of the situation. Five "conditioning" cards were used. Following this procedure the five original cards, one of which was mentally concealed, were presented and questioned. Of the five cards, that card eliciting the greatest G.S.R. deflection was assumed to be the falsely denied card. At the end of the experiment the subject was asked if that card having the greatest deflection was the concealed card. His answer was checked with the experimenter's report. Discrepancies were noted as well as their possible causes. The subject was asked to explain, as far as possible, unusual G.S.R. deflections for non-guilty cards.

The two conditions of the experiment differed in the following procedures. For Experiment A (control) the verbal instructions were:

> I am about to present you with five playing cards. You are to choose, to yourself, one of these five cards. This card you are to mentally conceal from me. Next I shall present you with a series of cards, one at a time. In this series of cards the card which you are mentally concealing from me will appear. I shall say to you when I present each card, "Is this the card?" To all cards, including the card of your choice, you shall say, "No it is not." It will be my purpose to indicate the card you have chosen and to reveal your deceit.

For the experimental condition (Experiment C) shock electrodes were placed about the calf of the left leg. Shock was obtained from an ordinary inductorium. The following instructions, designed to introduce emotional disturbance and fear into the inquisition through suggestion and intimidation, were presented.

> You are now in circuit with a psycho-galvanoscope, an apparatus capable of revealing deceit or dissemblance. This is one form of the well known lie detector. I am about to present you with five playing cards. You are to choose, to yourself, one of the cards. This card you are to mentally conceal from me. Next I shall present you with a series of cards, one at a time. In this series of cards the card you are mentally concealing from me will appear. I shall say to you when I present each card, "Is this the card?" To all cards, including the card of your choice,

> you shall say, "No, it is not." It will be my purpose to indicate the card you have chosen and to reveal your deceit.
>
> Bear in mind that this is a lie detector. By proper manipulation and interpretation of the results, I shall be able to tell you the card you have chosen. Although your verbal answer will not indicate the card, the psycho-galvanoscope will. Upon making the deceitful response you shall be punished with an electrical shock, such as this.

The subject was then given a shock, enough to make him jump. However, when the deceitful response occurred, he was not shocked. The shock was used to induce "fear" through threat and suggestion.

RESULTS: PRESENTATION AND INTERPRETATION

The data of the control condition, Experiment A, appear in detail in the *Transactions* (2) as Experiment A. The percentage of success in detecting deceit was 74 with 13 failures. Retest of four of the failures was successful with the exception of S 120. The statistical summary of the data is presented in Table I.

TABLE I. Summary of data of successful cases under conditions of experiments A and C

	Experiment A (Control) Non-guilty G.S.Rs	Experiment A (Control) Guilty G.S Rs	Experiment C (Shock) Non-guilty G.S.Rs	Experiment C (Shock) Guilty G.S.Rs
Mean	3.6 mm.	13.9 mm.	4.4 mm.	16.8 mm.
S.D.	2.66	6.91	3.095	7.24
S.E.$_m$	.38	1.106	.45	1.055
N	37 + 2 repeats		43 + 4 repeats	
Diff.$_m$	10 3 mm.		12.4 mm.	
S.D.$_{diff}$	1.172		1.147	
C.R.	8.8		10.8	
% succ's	74 %		86 %	

The data of the experimental condition, Experiment C, are likewise statistically summarized in Table I. The percentage of success was 86. There were 8 failures. Successful retests were made for four subjects. One of the retests was a failure in the first test, the others were promoted by the subjects themselves, claiming they thought they could "beat" the test. It may be seen from Table I that the reliability of differences between the averages of the guilty and the non-guilty G.S.R.'s for both Experiments A and C are more than three times necessary reliability. The absolute difference between the means (in mm.) of the guilty and non-guilty G.S.R.'s is greater for Experiment C than for A. The C.R. likewise is larger in Exp. C, despite the greater dispersion of the responses. This greater dispersion is probably due to added excitement introduced in this condition. The larger absolute difference between the means, the larger reliability of difference, and the greater percentage success suggest that in a condition of somewhat heightened excitement greater success in deception detection is obtained.

Table II presents a summary of statistical evaluations obtained through an examination of the data from various angles. Comparing the averages of the G.S.R.'s to non-guilty card responses of Exp. A and C we find an absolute difference of 0.8 mm. with a critical ratio of difference of 1.36. This difference is not reliable and no doubt is partially due to the greater dispersion of the G.S.R.'s under the condition of excitement in Experiment C. The chances are 91 in 100 that the obtained difference is significant—that the true difference is greater than zero in favor of conditions of Experiment C.

TABLE II. —Reliability of differences between non-guilty, guilty, and all G.S.R.'s of experiments A and C (successful cases)

	Non-guilty G.S.R.'s*		Guilty G.S.R.'s*		Aver. of Guilty and Non-guilty G.S.R.'s*		Non-guilty G.S.R.'s*	Guilty G.S.R.'s*
Mean	3.6	4.4	13.9	16.8	8.97	10.91	3.6	16.8
S.D.	2.66	3.095	6.91	7.24	7.49	8.56	2.66	7.24
$S.E._m$	.38	.45	1.106	1.055	.848	.882	.38	1.055
N	39	47	39	47	78	94	39	47
$Diff._m$	0.8		2.9		1.94		13.2	
$S.D._{diff.}$	.588		1.528		1.223		1.124	
C.R.	1.36		1.89		1.58		11.74	

*In mm. deflection.

Comparing the averages of the G.S.R.'s to the guilty card responses of Experiments A and C we find an absolute difference of 2.9 mm. with a critical ratio of difference of 1.89 (Table II). The difference is not regarded as sufficiently reliable. The chances are 97 out of 100 that the difference is greater than zero and in favor of the conditions of Experiment C. It might be noted that the excitable condition of a consciousness of deceit in both Experiments A and C is probably responsible for the greater variability of the magnitude of the G.S.R. deflections as indicated by the size of the standard deviation.

Comparing the averages of all the G.S.R. deflections, both guilty and non-guilty card responses of Experiments A and C, we find an absolute difference of 1.94 mm. (Table II). Though the difference is not reliable, the chances are the obtained difference will be greater than zero in favor of the conditions of Experiment C.

If the non-guilty responses of Experiment A are compared with the guilty responses of Experiment C, we note an absolute difference between the means of 13.2 mm. of deflection for the G.S.R. (Table II). This difference is greater than the differences noted in Table I. The reliability of difference is likewise greater as indicated by the greater C.R. of 11.7 (for Exp. A, 8.8; Exp. C, 10.8). The data thus evaluated strongly favor the condition of greater excitement, fear or apprehension, as presumably was induced in Experiment C through the threat of electric shock.

Using Garrett's (1 :227-28) formulae for the determination of the standard error of a percentage and the standard error of the difference between two percentages, we note a reliability of percentage difference expressed by a critical ratio of 1.52. The chances are 93 out of 100 that, on the average, a greater percentage success in deception detection will be obtained under the conditions of intimidation of Experiment C than under the conditions of relative non-excitement of Experiment A.

Judging from the reports of the subjects, the actual shock and threat of further shock elicited a condition which may be called fear. Anger followed in many cases. The shock was made sufficiently intense to induce fright. One subject became hysterical and could not proceed with the test. Several refused to go on with the test; and, as a rule, those subjects who participated in this experiment could not be induced to participate in further experiments. Reports of "cold sweat" were numerous. Thus it seems that "fear," which

elicits that so-called "cold sweat" is to the advantage of the G.S.R. as a deception indicator.

A detailed examination of the failures is instructive. Table III presents the detailed G.S.R. deflections for each card. Possible explanations were sought for the failures by inquiring of the subject: "What took place in your mind during the test?" S 60 came into the laboratory with the explicit purpose of foiling the test. He dipped his fingers in paraffin, thinking that that would prevent the passage of the current. The G.S.R. for the first conditioning card was small. This invited suspicion. However, the remaining responses were normal; it seems that the electrode solution eventually made contact with the sweat secretion through the paraffin. The failure to detect

Table III. The responses to each card for the failures in Experiment C

S's	2-H	A-D	10-S	3-C	4-S
60	3	2	(4)	22*	0
65	4	5	1	6*	(3) (repeat)
73	1	4	(4)	3	5*
75	20*	(15)	0	3	3
81	19*	4	13	(15)	16
88	1	(4)	9	4	15*
89	0	(12)	2	15*	2
90	12	10	(9)	18*	5

( )—the mentally concealed card.
* —the experimenter's selection.

the right card was due to the introduction of an artifact. The deflection of 22 mm. for the 3-C was the result of genuine G.S.R. of 2 mm. plus a change in contact of the finger resulting in an increased deflection of 20 mm. The subject "squeezed" his fingers against the clay cups, distending the skin. It so happened that the squeezing took place after the genuine response was at its peak. The "squeezed" deflection was just rapid enough to invite further suspicion. But, because of the latent time of the genuine response, the entire deflection was given credence as a possible G.S.R. Thus the experimenter selected the 3-C as the guilty card. If the judgment had been based on the genuine response, or had the G.S.R. been photographically recorded, the correct card would have been selected.

The failure of the first test of S65 was due to a "suspected" lie in reporting the real card which he was concealing. He would not admit after a retest that his card for the first test was the 4-S. But he was too eager for a retest. Upon retesting, the card which he was concealing was marked on a piece of paper by him, a precaution to prevent further "lies." The second test was successful. S65 was so impressed by the success of "both" tests, that he bet S66 that he could not beat the test.

In the case of S73, the failure was due to the neglect of the experimenter to record a succeeding G.S.R. resulting from the subject's expectation to receive a shock. When the 4-S was presented, the subject claimed that doubt rose in her mind as to which card she was concealing, because, she claimed, "Since I did not get a shock when I denied the 10-S, I thought perhaps I was mistaken about the card." S75 could not account for the high deflection for the 2-H. S81 was highly excited within, judging from the number of intermediate G.S.R.'s, a difficulty which prevented readings for the respective cards. It was interesting to note the apparent calmness which she displayed on the surface. The case of S88 cannot be explained. S89 intended to pick the

3-C; the large deflection accompanied her recall of her intention when she saw the 3-C. In the case of S90, the deflection for the 3-C resulted from his expectation to receive a shock. The 10-S was his choice. When he perceived this card two deflections occurred. The first deflection was recorded as the response to the apprehension and denial of that card, while the second deflection was thought to be a response resulting from the anticipation of the next card. As a matter of fact, the second deflection was the result of the subject's realization that the 10-S was the card which he had decided to conceal. When the following card was presented he was expecting a shock; thus the high deflection for the 3-C.

SUMMARY AND CONCLUSIONS

The action of fear, induced by means of shock intimidation and suggestion upon a deception test when the G.S.R. is used as the deception indicator, was investigated. The deceit situation consisted in the denial of a selected card by the subject. A control and experimental deceit situation was used. In the experimental condition the subject was shocked, threatened with further shock, and advised of the efficacy of the apparatus as a "lie detector." Under the experimental condition of shock, greater success in detection of deceit was obtained. It may be concluded that the so-called "cold sweat" of excitement, induced through fear or apprehension, as occurs under laboratory conditions, does not make ineffective the G.S.R. as a deception indicator; on the contrary, under the conditions herein described, it enhances the effectiveness of the response.

LITERATURE CITED

1. Garrett, H. E. Statistics in Psychology and Education, New York, Longmans, 1939
2. Geldreich, E. W. Studies of the Galvanic Skin Response as a Deception Indicator, *Transactions of the Kansas Academy of Science*, 44, 1941, 346-351
3. ———. The Use of a Calibrated Potentiometer in the Measurement of the Galvanic Skin Response, *American Journal of Psychology*, 47, 1935, 491-93
4. Larson, J. A. Lying and Its Detection: a Study of Deception and Deception Tests, Chicago, The University of Chicago Press, 1932
5. Marston, W. M. Studies in Testimony, *Journal of the American Institute of Criminal Law and Criminology*, 15 (May), 1924, 5-31
6 Poffenberger, A. T. Can Psychology Aid in the Prevention of Crime?, *Police Journal*, 9 (June), 1922

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Further Studies of Learning Aptitude in Pilots—A: Prediction of Flying Aptitude

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Last year at the annual Kansas Academy of Science meeting I presented a paper advancing a method for selection of pilots in the Civil Aeronautics Administration programs of Fort Hays Kansas State College. The method embodied careful consideration of the qualifications of flight applicants; from the data obtained, a formula for selection was worked out. In this formula certain qualifications were given appropriate weighting in such manner as to give the best picture of the necessary attributes in predicting success in flying. As criterion of flying ability, fifty-five trainees were rated by the flight operator and the flight examiner on master sheets, on which the individual was given numerical rating and on which the raters could make man-to-man comparisons of the fliers.

It was found that the ratings of these two judges correlated .60 ± .09, thus establishing a reasonably sound criterion for our study. At the beginning of the program considered in the previous study, each applicant was given a rating by a flight committee selected for this purpose. We computed correlations between these original ratings and those given by the flight operator and the flight examiner. These original ratings correlated .45 ± .07 with the flight operator's final rating and .27 ± .08 with the flight examiners 'rating.

We then combined scores obtained by the verbal test—"Henmon-Nelson Test of Mental Ability for College Students, Form A"—and scores on the performance test, "The Kelly Spatial Insight Test." We then combined the two flight rating scores. The correlation between test scores and flight scores was .405 ± .077.

After considerable calculation, the following formula for selection was worked out:

$$\text{Flying Aptitude} = \frac{V - \bar{V}}{\sigma s} + \frac{S - \bar{S}}{\sigma s} - \frac{W - 45}{10} \; (+1) \text{ for career interest}$$

Where: $\dfrac{V - \bar{V}}{\sigma s}$ = Verbal test deviation score in standard units.

$\dfrac{S - \bar{S}}{\sigma s}$ = Spatial insight test deviation score in standard units.

W = Weekly work load in hours.

After consideration of our data and applying our formula to it, we arrived at a correlation of .703 ± .047, considerably above that anticipated.

This study was intended to show the advisability of appropriate psychological tests in the selection of young men entering the air services. In our present national emergency, the immediate placing of qualified men, or rejection of unqualified men, in our air services is vital to our nation's defense

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and to our nation's budget. To my knowledge, the Army Air Corps still has no psychological method of selection of applicants but relies only on the so-called neurological examination which consists in looking at scars on the tongue as evidence of epilepsy and similar haphazard devices. The physical examination has been modified. However, our Army Air Corps has recently initiated research units for formulating more exact methods of selection. It is the purpose of these papers to point out some of the possibilities and practicability of such measures.

In the present study twenty-nine flight trainees were rated at the end of their training period by the flight examiner and flight operator. The correlation between the two ratings on these twenty-nine trainees was .90 ± .035. The correlation between the two ratings on the total number of trainees taken into consideration on both studies, was .755 ± .054.

Data obtained on these latter twenty-nine applicants was correlated with the criterion. These trainees had been selected by the method outlined in the previous study. The correlation between ratings as given these men before beginning training and those assigned to them by the flight operator and the flight examiner was found to be .134 ± .015. At first glance this seems incompatible with expected results. On further consideration, however, it is seen that this is exactly what might now be expected. We now have a select group with which to deal; one in which intelligence, insight and work loads have been taken into consideration and made fairly homogeneous. Now individual differences among the group must be attributed to other variants not taken into consideration. Chief among these is motivation, which will be given further consideration in the following paper. We have now held several variants constant and the motivation variant has come strongly into play; emphasized undoubtedly by the present crisis. Thus we find little correlation between the factors held constant and the final ratings. The factor of motivation is influencing the relative success or failure of individual trainees.

Another factor evident in this course which should be taken into consideration is what might be termed—although not accurately—the "ceiling effect." Students are given a minimum standard which must be attained. Those men are selected who, on the basis of their individual qualifications, can attain this standard, thus cutting off our distribution on the lower end. Those above this standard are a more homogeneous group in intelligence and other factors, and we can expect these variables to exert very little influence in the correlation. In other words, when one variable in a correlation is restricted in dispersion, the correlation is sharply reduced. Other variables not taken into consideration are influencing it.

LITERATURE CITED

1. MATHENY, WILLIAM GUY—The Effectiveness of Aptitude Testing in the Civilian Pilot Training Program. Trans. Kans. Acad. Sci. v. 44, 1941, 363-65.

Further Studies of Learning Aptitude in Pilots—B: Prediction of Ground School Aptitude

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The Fort Hays Kansas State College Flight Selection Committee has been using a psychological testing program for the selection of applicants for the Civilian Pilot Training Program. Matheny (1), who is a pilot himself, has done some work on the prediction of success and flying aptitude for prospective pilots. This paper concerns the prediction of success in the ground school part of the training.

Upon completion of the private course, the pilot must pass an official Civil Aeronautics Administration final written examination. A passing grade of seventy percent must be made in each of the four parts of the examination. Each part contains twenty-five questions. This number of questions means that the student cannot miss more than seven questions on each section or he fails to receive his private license.

We first sought to know whether or not the intelligence factor greatly influenced the success of the student. We therefore compared the scores made on the "Henmon-Nelson Test of Mental Ability for College Students" and the final official "Ground School Examination." The correlation proved to be .13 ± .07. Since this correlation was of small consequence, we wondered whether or not the average grades on all previous college credit was a reliable prediction factor. Correlation between grade points and the scores obtained on the final official test were computed. A correlation coefficient of .09 ± .01 was obtained. We examined the grades given by the ground school instructors and the Henmon-Nelson test scores to find a correlation of .16 ± .06.

We then decided to try modifying the grade points in the light of these other variables in order to make a better prediction of ground school grades. We arrived at a combination prediction score by taking the grade point average in previous courses and modifying it as follows: for each standard deviation of intelligence we raised or lowered the grade point average two tenths; next, we added two hundredths for each one percent of background courses. These weights were decided upon by inspection of the scattergram between the official examination grades and the college grade point averages. They were not determined by multiple regression. The correlation between the Civil Aeronautics Administration official grades and the combined prediction score is .33 ± .07, still scarcely significant.

We wondered if an emphasis upon certain physical science courses of the student's previous college experience might not be an important factor in their success in the ground school course. On relating the total number of hours, not percentage, of training in background courses in physics and mathematics, to the final examination grades, we found the correlation again to be practically zero.

The Flight Committee of the College has been using a process of selecting students on what is called an "aptitude scale." Matheny has described the method for selecting students on the basis of flying aptitude in Part A of this paper. The "Ground School Aptitude Score" consists of combining the following factors: interview scores given by the ground school instructors on

a rating scale between one and fifteen, inclusive; the raw score made on the Henmon-Nelson test; the amount of grade point average above C, times ten; and one-half of the total credit hours in mathematics, physics, industrial arts, and mechanical drawing. These were considered in a rather broad way as background courses. The correlation of the Civil Aeronautics Administration final examination and the ground school aptitude score obtained in this manner is approximately zero.

Probably the most striking correlation is the one between the ground school grades in the subjects of navigation and meteorology on the final official test and those given in these subjects by the ground school instructors, which is only .37 ± .07.

From these results, it appears that ground school grades do not correlate with any of the usual measures of aptitude. Three possible explanations might be suggested:

ONE. The students who took the course were all subjected to our formula and had to meet the Committee's requirements; that is, were required to reduce their scholastic and work loads, meet a minimum grade point average, and minimum test scores. These requirements then, would reduce their variability in those factors which we have tried to correlate with ground school success. With the variability reduced we naturally expect a reduction in correlation.

TWO. The course has been set-up to meet minimum standards rather than to exploit each student's maximum ability. Such standards mean that variability of the dependent variable, ground school success, is reduced. That is, in the classroom, the able students are not particularly stimulated to extend themselves while the less competent students are carefully coached until they can meet the minimum standards. This factor also would reduce the correlation between aptitude and ground school grades.

THREE. The extreme amount of motivation in some cases, and hence, the greatly extended variability of this factor which is associated with flight training courses, tends to mask other variables such as the intelligence factor. Of course, we have no way to measure this motivation factor objectively. Some cases illustrate the effect of motivation:

One case was a typical football addict making A's in that subject only. It was observed however that in courses which are related to the field of aviation, that is, welding, mathematics, and physics, he made better records. At the beginning of the fall 1940 session, this student transferred his credit to this college from another state school. He had obtained twenty-five hours credit making an average grade point of 2.68. Shortly after the second nine weeks' period of the fall semester began, he applied for flight training to be taken during the spring 1941 program. The coordinator told the student that if he would bring in at least one B and no D's for his semester grades, he would be eligible to take the training; provided, of course, he could pass the physical examination. The student not only complied with that requirement but did somewhat better. He brought in two B's. Even nine pounds excessive weight did not discourage his efforts. He lost these by sitting in a steam room for several hours. The student made an A in the Private Course and a score of ninety-two on the official Ground School Examination. During the fall of 1941

session, he took the Secondary Course in which he made another grade of A. His other grades had improved so much that his grade point average at the end of the second semester of flight training was 3.64.

Another case made an appreciable increase in his grade point average after enrolling in the flight training courses. He raised his average from 2.98 to 3.10 the first semester of his training and on the official Civil Aeronautics Administration final examination made a score of 100%. It is interesting to note that in related engineering courses, that is, in mathematics and physics which he had taken previously to his flight training, his grades were better than in non-related subjects,—biology, psychology, business law, and geography. It is also interesting to note that after the student took a full time job and cut his college program to eight hours, five hours advanced aviation, and three hours trigonometry, his grade point average again increased.

One individual applied for flight training twice before he was finally accepted by the Selection Committee. His score on the Henmon-Nelson test was in the lowest ten centiles and his previous grade point average was 2.71. His score on the official Civil Aeronautics Administration final examination was 82% His grade point increased to 3.10 during that period and his grades have continued to improve since he began training in the field of aviation. Apparently interest in aviation has motivated him. Last fall he completed his aviation training and received a commercial license with an instructor's rating. He is now employed by an army contract school with a contract that provides for a salary of $350.00 a month by the end of the year. Again, motivation has pushed aside other variables which ordinarily would have prevented his success.

LITERATURE CITED

1. MATHENY, WILLIAM GUY. The effectiveness of aptitude testing in the Civilian Pilot Training Program, Trans. Kan. Acad. Sci. 44, 1941, 363-65.

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Recent Development in Clinical Psychology

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I.

The present national emergency provides an opportunity and makes it highly desirable to clarify the development, position and value of the science and profession called clinical psychology. There are several reasons for a clarification: First, the clinical psychologist has been in a steady professional competition with the psychiatrist in the field of therapy and counseling; secondly, the clinical psychologist was about to become a mere I.Q.- and questionnaire-technician or a research man whose employment has been considered a luxury. However, recent development in clinical psychology has made for a cooperation between psychiatrist and clinical psychologist. Such cooperation and mutual complementation of each other's work is of utmost importance at a time of emergency, especially when the supply neither of psychiatric nor of well-trained psychological personnel appears to be abundant.

Clinical psychology was born of an attempt of psychologists to apply their knowledge and experimental methods to making clinical work—mostly built on observation, interview, and subjective evaluation—more objective. The objectivation of intelligence estimation into the form of testing for intelligence quotient, the crystallization of the method of trials in judging skills into aptitude testing, and the systematization of interviews of different kinds into questionnaires were important steps ahead in building an objective clinical procedure. However, they contributed to the clinical psychologist's becoming one-sided as to his training; the learning of the technique of testing took the greater part of his training period, precluding the possibility of a thorough study of personality organization and psychopathology. Those clinical psychologists who achieved a working knowledge of psychopathology and of personality did so in their field experience rather than in training. Recent advancements in clinical psychology are causing this picture to change considerably.

II.

The new viewpoint of clinical psychology centers around the problem: How to obtain knowledge of the subject's personality, of his abilities, of his problems without resorting to the usual method of taking case history. The underlying principle is the same as that of projective techniques. This principle states that the human individual reveals his personality in every one of his activities; in other words, he projects his "private world" into his actions, his choices, and the modes into which he organizes his actions. Thus the personality, its capacities and problems, may be inferred from a well-chosen field of activity observed, registered, and analyzed with sufficient care and on the basis of sufficient experience. This new line of work makes the clinical

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psychologist more than a test technician to report I.Q.'s, percentile ratings of aptitudes, and so on. He becomes a well-nigh indispensable companion of the psychiatrist, of the educator, and of the personnel manager, as he has means by which to obtain rapidly personality description, clinical diagnosis, and even prognosis—independently of those derived on the basis of case history. Where careful histories are obtained, he offers a desirable checking medium; where this is not the case, his role becomes even more significant. Also, the new methods make for a change in interest, professional equipment, and training of the clinical psychologist; their technique is infinitely simpler than that of the routine intelligence test—their study is a study of the dynamics of personality.

I shall describe the battery of tests used in the work of the Department of Psychology of the Menninger Clinic which has been found sufficient to give a detailed description of the personality and the disease of the patient. For completeness we use this battery of six tests in our routine, but in many cases two or three tests will already give satisfactory results. I shall describe the general ideas underlying these tests, which in themselves and in their application represent the latest advancement of clinical psychology.

Usually we first give an intellingence test. We obtain the I.Q.; our point in giving the intelligence test is, however, not to get the I.Q. itself. It has been known to clinical psychology that the range of mental years over which the performance of the subject is scattered is significant. Some clinical psychologists even made inferences concerning intelligence development from the type of item missed below and type of item passed above the general mental age level of the subject. Much less known is the fact that if the test items are grouped according to the psychological functions involved in them, the partial scores thus obtained will give an understanding of the psychological assets and disturbances present. It is possible furthermore to correlate the relation to each other of the scores of certain of these groups of items with definite clinical pictures. The lack of a systematic selection of items in the construction of the Stanford-Binet test does not make for easy application of these principles to it—although we found such application possible. The intelligence test which yields readily to such treatment is the Bellevue-Wechsler Scale (1). In this test no year grouping of items is given. The test is divided into ten groups of items: Comprehension, Information, Digit Span, Arithmetic, Similarities, Vocabulary, Picture Arrangement, Picture Completion, Block Design, Object Assembly, and Digit Symbol. The weighted scores of these items are charted on a card, yielding a scattergram which in some cases is in itself a sufficient basis for clinical diagnosis. Naturally, the details of such diagnosing cannot possibly be discussed here. It can be stated, however, that the width of the scatter in general, as well as conspicuous deviations of single items from the central tendency are the bases of the diagnostic procedure.

The intelligence tests are followed by the administration of tests showing the efficiency of the intelligence. For this purpose the so-called concept formation tests are used. Concept formation, that function of the human being by which he automatically links up similar and separates dissimilar objects, facts, experiences, is—according to extensive investigations—the basic function underlying thinking; this function is extremely sensitive and one of the first to

be impaired whenever a psychic disturbance is present. We found two extremely useful methods of testing concept formation. One is the Sorting Test (2, 3) : the subject is asked first to select from among thirty-odd objects of everyday use those which "belong with" given sample objects and then to state why a given group of objects belongs together. While this test probes into the surface of concept formation, the other, the Hanfmann-Kasanin Test (4), goes deeper. The task is to group 22 blocks varying in form, shape, color, height, and width into four consistent groups. The subject's ability to find solutions, to take clues showing that his solution is incorrect, and to utilize these clues towards a better solution shows the reaction of the subject to failure and success, shows his wealth of ideas, his method of reasoning—that is, it shows the personality in action. We cannot dwell here on details. We may state, however, that either one of these tests is frequently sufficient to arrive at a definite clinical diagnosis as well as to the description of the central characteristic or difficulty of a practically normal person.

After having tested intelligence and intelligence in action, we usually turn to the so-called projective personality tests. These yield a scheme of the personality make-up. The tests are based on the assumption that when a human being is confronted with an unorganized situation or with multiple possibilities of choice, his manner of organizing the situation as well as his choices will be unique and revealing of his personality. The most important of these projective personality tests is the Rorschach Test (5, 6). In this test ten ink blots, gray, black and bright-colored ones, are presented to the subject with the question, "What might this be?" the responses are recorded and sorted as to what portions of the ink blots, wholes or parts, were interpreted, as to what the content of interpretation was, and as to whether the form, color, shading, and so on of the area interpreted had served as the basis of interpretation. This sorting yields results expressed in numbers which then serve as the subject matter of interpretation. They yield information concerning the natural endowment of the person, the efficient wealth, efficient acuity, flexibility or rigidity of his intelligence; they give information about emotional stability versus liability, emotional inhibition versus freedom, emontional adaptivity versus impulsiveness or over-suggestibility; they register anxieties, general attitudes, and frequently even direct concrete problems of the person.

The projective personality test complementing this is the Szondi Test (7). Six series of photographs are shown to the subject. Each of these six series contains a picture of a homosexual, a sadistic murderer, an epileptic, a hysteric, a paranoiac, a manic, and a depressive patient. The subject is asked to choose of each series the two most liked and the two most disliked pictures; these choices are recorded on a profile. The profile is then interpreted. Similarly to the Rorschach Test, this test yields personality description as well as clinical diagnosis. The patient suffering of a certain mental disease will either not choose any of the corresponding photographs or will choose all of them. Thus the maxima and minima in the graph are the diagnostic means. The Rorschach and Szondi tests yield the general personality scheme underlying the functions registered by the intelligence- and concept-formation tests.

Having thus obtained three different types of schemes of the subject's mental functioning, we usually want to obtain information about the thoughts and fantasies he is preoccupied with. For this we use the Thematic Apper-

ception Test (8, 9). In this test twenty pictures of various life situations (of old and young, male and female, attractive and repulsive figures) are represented. The subject is asked to make up a story around each one of the pictures. The stories thus constructed tell us, when carefully analyzed, with what types of people the subject identifies himself, with what types of problems he sees himself confronted in life, what kinds of aims he pursues and by what kinds of obstacles he feels himself confronted. The material obtained with the aid of this test fills with flesh and blood the schemes obtained by the tests described above.

III.

The means here described are but samples of the means that recent development has put at the disposal of the clinical psychologist. We have chosen these samples because in our experience they have constituted the backbone of an exhaustive routine examination. However, many similar techniques are at the disposal of the clinical psychologist and with their aid he can attack levels of different depths and of different degrees of intellectualization of the human personality. These means can be used in educational and vocational counseling as well as in psychiatric clinical work; they are actually used by us in such situations also. Their application to industrial, marital, etc. counseling as well as to problems of military psychology are being undertaken in different parts of the country and are also in progress in our department.

These new means of attack result in the independence of the clinical psychologist from the usual methods of history-taking and observation and also in the independence from competing with the psychiatrist's method and practice. In fact, they make the clinical psychologist indispensable for the psychiatrist.

The speed and accuracy of work afforded by these methods render them a highly valuable means in times such as ours, when personnel problems gain increasing importance. The national emergency requires utmost economy with human values and human efficiency, and—as we have just described—the science of clinical psychology has today means at its disposal to cope with the demands thus arising.

REFERENCES

1. WECHSLER, D. Measurement of adult intelligence, Baltimore, Williams & Wilkins, 1939
2. WEIGL, E. On the psychology of so-called processes of abstraction, J. of Abn. and Social Psychol. 36, 1941 3-33, Trans. by Margaret J. Rioch
3. GOLDSTEIN, K. and SCHEERER, M. Abstract and concrete behavior, an experimental study with special tests. Psychol. Monog. 53, 151, 1941
4. HANFMANN, E. and KASANIN, J. Conceptual thinking in schizophrenia, Nerv, and Ment. Disease Monog. No. 67, 115, 1942
5. RORSCHACH, H. Psychodiagnostik. Methodik und Ergebnisse eines wahrnehmungsdiagnostischen Experiments (Deutenlassen von Zufallsformen), 3rd ed., Bern, Morgenthaler, W., ed., 1937
6 BECK, J. Introduction to the Rorschach Method, Menasha, Wisconsin, Amer. Orthopsychiat. Assoc., 1937
7. RAPAPORT, D. The Szondi test, Bull. Menninger Clinc., 5, 17-25, 1941
8. MURRAY, H. A. Explorations in personality, New York, Oxford Univ. Press, 1938
9. MASSERMAN, J. H., and BALKEN, E. R. The clinical application of phantasy studies, J. of Psychol. 6, 81-88, 1938

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The Purpose, Origin, Plan of Procedure, and Values of the Nation-Wide Every Pupil Scholarship Tests

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PURPOSE

In the field of measurements and the objective testing movement, the Nation-Wide Every Pupil Scholarship Test is one of the major significant developments. Because of the far-reaching influence of these testing programs in this respect, it was felt that it would be worthwhile to recount the major details of their purposes, origin, methods of procedure, and values.

The purpose of the Every Pupil Scholarship Tests is the promotion of scholarship. They are a valuable agency for stimulating scholastic endeavor on the part of the students. They stimulate good teaching as well as application to better learning. They vitalize education and make schools more worth-while in the lives of the students.

ORIGIN

The Nation-Wide Every Pupil Scholarship Tests sponsored by the Bureau of Educational Measurements of the Kansas State Teachers College of Emporia had their origin twenty years ago in connection with the county and state scholarship contests sponsored by this college.

The first county contest in academic subjects, of which we find a record, was conducted by the Bureau of Educational Measurements in 1922 in Cloud County, Kansas. The first state scholarship contest on record was conducted by the Emporia State College in 1923.

For a time the county contest movement was very popular, and the state contest movement also developed at a marked rate. The latter is still a popular event in Kansas. This spring the twentieth annual state scholarship contest will be conducted by the Emporia State College at thirty conveniently located centers of the State. Last spring over 3,500 students from approximately 200 high schools participated in this event.

In the county contests at first only a few of the best pupils participated from each school. Hence the suggestion was made that a plan be devised which would stress excellence in achievement of the entire class in a curricular field Thus in the spring of 1924 two schools conducted a contest in one subject which involved a larger number of pupils from each school, each set of pupils taking the tests in their own school. The test papers were provided and scored by the Emporia State College. This was known as a dual contest. During the 1924-25 school year there was much demand for objective tests for use in similar inter-school contests in which every pupil in one or more specified subjects of each of the competing schools participated. Because of the increased demand for new tests for this purpose, a plan was devised for announcing in advance the subjects and dates for which tests would be made available for inter-school competition. During the first year that this plan was in operation, many schools used the tests for inter-school competition in

which all the pupils of each school participated and the median score was used as the measure of comparison. A few schools, however, were not matched with any other schools for competition, but they desired to use the tests in order to be able to compare their results with the results of the other schools for the purpose of determining the relative excellence of their own classes. Hence norms were computed from all scores in each subject and provided to all the participating schools. Thus the *Every Pupil Contest* idea soon was superseded by the principle of a testing program in which schools voluntarily participate in order to obtain an objective measure of the attainment of pupils and classes. This is the plan that has been retained in the main, with the introduction from time to time of valuable perfections and improvements.

PLAN OF PROCEDURE

At present the plan of procedure of the nation-wide *Every Pupil Tests* is as follows. The Bureau of Educational Measurements annually announces two dates for the testing programs. These come at the close of the first semester and near the middle of April. Bulletins are sent out giving the list of subjects for which new tests will be provided for each testing date. This year thirty-four new tests were provided for the testing program scheduled for January 8, and forty-four tests will be provided for the next testing program announced for April 8. Approximately 1,000 schools of the country obtain tests at mid-year and 1,500 for the end-of-year test. About three-fourths of a million copies of the tests are used annually.

The Bureau secures competent volunteers to construct the tests. These consist usually of teachers in Kansas and elsewhere who are well trained in their respective curricular fields and who have also had some training in the field of measurements. The tests are edited at the Emporia State College by test construction and by curricular specialists. The printing is done in the college print shop. Several dozen student assistants are employed in the office of the Bureau and in the print shop to handle the routine duties of typing, proofreading, filling and shipping of orders, summarizing scores, computing percentile norms, invoicing, and keeping accounts.

As test orders are received from all parts of the country, norms are computed from the scores reported by the participating schools for each curricular field both for the whole group and also separately for individual states from which a sufficient number of scores are reported to warrant it.

A summary bulletin of results is printed in compact form and furnished *gratis* to all participating schools within three weeks after the scheduled testing date.

For one of the recent *Every Pupil Scholarship Testing Programs* it was found that the process of computing the measures reported in the *Summary Bulletin of Norms* entailed the handling of 162,412 pupil and class scores, the construction of 405 frequency tables, and the calculation of 3,429 statistical measures. The norms computed are based on from several thousand to over ten thousand pupil scores for each of the various school subjects and grades for which the tests are provided.

VALIDITY AND RELIABILITY

What method is used to insure that the tests possess adequate validity and reliability, the most important criteria for evaluating tests, is a question worthy

of consideration at this point. While it is not claimed that the tests are fully standardized, they do compare favorably in these respects with the better standardized publications.

For insuring validity the following precautions are taken: First, as a rule the test builders are persons who teach classes in the curricular fields covered by the tests and who therefore have a good perspective of the content to be included. Second, content studies are made of textbooks and courses of study and the test items budgeted in accordance with the content distribution. Third, the editors consist of test construction specialists and supervisors and teachers of curricular fields. Fourth, cumulated studies of pupil responses on test items over a period of years are available and used. Fifth, cumulative criticisms from teachers who have used the tests over a period of years are available and utilized. Sixth, in fields where studies from previous editions of the tests are not available, preliminary editions are provided and tried out in representative classes.

For insuring reliability, studies are made with preliminary editions and on tests provided over a period of years. In a field where tests are regularly provided, the degree of reliability may thus be predicted with a fair degree of accuracy.

The results are used extensively by teachers, principals, and pupils. Many expressions are annually received from schools as remote from the center of this movement as Montana, Florida, Texas, Maine, and California. Teachers are eager to learn how their classes rank in comparison with the classes of dozens of other schools in which the tests were administered on the same day during the current school term. Moreover, they want this information without much delay. It must be available promptly during the current school year to be of maximum value to them. Thus far we have been able to live up to the goal of mailing the results to the schools within three weeks from the day the tests are administered.

Pupils, too, are eager to note how they rank in comparison with the pupils in their own and other schools and they want this information before it becomes ancient history. By providing objective measures which can be simply and intelligently interpreted, pupils are motivated to work for greater excellence in achievement in the various curricular fields.

Many principals conserve the test results from year to year by filing the cumulative record of each pupil on a convenient card which has been provided. Because all scores are similarly interpreted, this provides a wealth of material for use in counseling and personnel work. Some schools also issue certificates of excellence to pupils whose scores receive a high percentile rank. In this manner excellence of achievement is further stressed and motivated.

VALUES ACCRUING FROM THE PLAN

The values accruing from the *Every Pupil Scholarship Tests* are manyfold. These may be roughly classified as primary and as secondary values. The major primary values are the following:

A. The plan of the *Every Pupil Scholarship Tests* stimulates an intelligent interpretation of test results. For this purpose, percentile scores are provided for each subject and grade. Simple instructions are given for interpreting class median scores, as well as individual scores, into corresponding percentile scores. Because many different methods of

interpreting standard test scores are resorted to, teachers are frequently at a loss in regard to the procedure in making correct interpretations. All too frequently valuable results from the use of standard tests are misinterpreted or not interpreted at all. Through our process of education in this respect over a period of years, many teachers and principals have exhibited that they have learned to make correct and meaningful interpretations of their results by the percentile score method and that they like the simplicity of this method.

B. The plan motivates pupil and class effort because the results are objective and the interpretation is intelligible not only to teachers but can be presented graphically and intelligently to pupils.

C. The plan motivates teachers in the construction and use of better home-made tests.

D. The plan motivates teacher effort in better planning of instruction, finding of weaknesses of instruction, and so on.

E. The plan motivates diagnosis of weaknesses and of efficient remedial work in instruction.

F. The plan challenges the teacher to set up outcomes objectives and to look for methods of determining the extent to which such outcomes are realized. Too frequently teachers are content in the assumption that valuable intangible outcomes accrue from their instruction, when in reality this may be far from the true conditions. By being consistently exposed to objective measurements, it is hoped that in time they will become skeptical of these assumptions and seek to evaluate the actual lasting values of their efforts.

Among the secondary values, the following are a few of the more obvious:

A. The plan aids the test builders to become more proficient in devising more efficient and valuable tests.

B. On the Emporia State College Campus the plan aids several dozen students annually who need employment to finance their college education.

C. For the measurements classes on the campus, the plan provides an invaluable laboratory. All of these students are in some concrete measure exposed to test production, standardization, use, scoring, interpretation, and so on.

D. The plan affords unusual opportunity for teaching students in measurements classes and other employees the use of mechanical devices in handling statistical and other data. For example, the Bureau office contains hand and electric calculating machines, comptometer, clip boards, postal rate scales, postal wrapping device, and Dictaphones. The college print shop is equipped with linotype, rotary press, folding machine, stapling machine, and other equipment essential to a modern printing establishment. A large number of students receive first-hand experience in the operation of these devices in connection with their employment made possible by the nation-wide *Every Pupil Scholarship Tests.*

E. The plan of the *Every Pupil Testing Programs* makes it possible to standardize more and better tests than would otherwise be possible. Where normally scores for norms would be difficult to obtain, and at considerable cost, a much larger sampling is possible for the norms and at practically no cost. This makes it possible to pass the advantages on to the patrons in terms of more and better up-to-date tests at an unusually low cost of production. During the writer's directorship of the Bureau of Educational Measurements, fifty-seven tests have been standardized. Most of these are published by the Emporia State College, but a few are published by some of the other leading test publishers.

F. For many schools, participation in the nation-wide *Every Pupil Scholarship Tests* has furnished excellent material for local school publicity. In this manner taxpayers and patrons are made aware that their schools are not only seeking to excel in the so-called extra school work, but also in the regular curricular fields.

G. Capable pupils through use of these tests make a discovery of their own scholastic potentialities and are inspired to seek further development in college who otherwise might be content to terminate their education upon junior or senior high school completion.

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A Study of Individual Variations on Similar Learning Tests

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The purpose of this investigation, in the field of individual differences in learning, is to find qualitative and quantitative differences in the learning process of a small group of college students on familiar, non-verbal patterns and on simple verbal material organized into learning tests.

The criterion for comparison was the Bronner-Healy Learning Z test published by C. H. Stoelting Company, Chicago. This association test, containing non-verbal material, consists of six rows of geometric symbols such as a (L,O,=, X) square, circle, triangle, cross, etc., with eighteen in a row and a key at the top. The key has a number for each symbol ranging from one to eighteen consecutively. The subject copies the appropriate number from the symbol on the key to be placed on similar symbols of the first exposed row. One minute is given for copying and learning. The subject then folds down from sight both the key and the exposed row and attempts by looking at the geometric symbols on the newly exposed row to associate the correct number with each symbol. The process of copying, recalling, and associating is repeated until the pairs of rows of eighteen symbols in each have been attempted. The score on the even rows are summated. The highest possible score is 54.

Four other tests, constructed like the Learning Z test, but substituting other material instead of the symbols, were devised. In one test nonsense syllables were used, thus introducing verbal non-meaningful material. In another, actual colors such as red, green, blue, etc., were supplied. In still another drawings of the outlines of familiar animals, were used, thus emphasizing form; while the fifth contained the names of colors as the word "red" "green", etc., emphasizing meaningful simple verbal material. These five tests known here as nonsense syllables, color word tests, animal tests, color tests, and Learning Z were given a week apart in the same manner to 63 college students. The group was academically above average.

The reliability measures of the four home-made tests were found by giving the same tests twice to the same group of students after a time interval of one week had elapsed. The student groups upon which the reliability coefficients were secured were different from the experimental group; these last being summer school students. The coefficient of correlation using the Pearson Product Moment Formula of the first with the second for the four tests were:

(1) Animal	N=60	r=.62
(2) Color Word	" =43	"=.83
(3) Nonsense Syllables	" =38	"=.74
(4) Colors	" =47	"=.76

Since the criterion Learning Z was a standardized test, no attempt was made to determine its reliability.

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TREATMENT OF DATA

Table I shows the correlation coefficients, inter-correlations between the Learning Z and each of the four other tests.

TABLE I. Correlations and intercorrelations between the criterion learning Z and the four variables.

Learning Z and Colors	Animals	Color Words	Nons. Syllables
.37	.13	.41	.44
	.34	.45	.40
		.48	.24
			.63

An inspection of this table reveals that there is a positive, but low, relationship existing among the tests, with the exeception of color words with nonsense syllables. Evidently, since the reliability coefficients, although high, were consistently higher than the correlations among the five tests, the particular ability used by a student in learning one test did not carry over to similar materials on other tests.

Another way of showing the variability of subjects on the same tests is to compare their performances on each of the five tests by means of the ratios of the averages over sigma differences or critical ratios. It could be assumed, then, that the significant differences among the tests would be a measure of learning difficulty. In order to illustrate these differences the following statistical data, as shown in Tables II, III and IV, has been prepared.

Table II shows the significant measures of each test, i.e., the mean, standard deviation, and standard error of mean by standard formula.

TABLE II. Central tendencies, dispersions, and reliability of Central Tendencies N 63

	Learning Z	Color Words	Animals	Color Tests	Nons. Syl.
Means	44.72	36.28	34.83	29.90	29.43
Sigma	7.95	10.47	9.09	11.20	8.52
S.E. of the mean	1.00	1.32	1.14	1.40	1.07

TABLE III. Standard error of the difference or Sigma difference between the means by standard formula

Learning Z	Color Words	Animals	Color Tests	Nons. Syl.
	1.65	1.51	1.68	1.46
		1.74	1.92	1.69
			1.46	1.56
				1.72

TABLE IV. Differences of the means over Sigma differences*

Learning Z	Color Words	Animals	Color Tests	Nons. Syl.
	5.11	6 54	8.82	10.15
		.83	3.33	3.77
			2.70	3.16
				.26

*Difference ratios or critical ratios which must be three times or more to indicate a difference greater than zero for the tests.

It is evident from an inspection of Table IV that Learning Z is the least difficult and that this difficulty increases steadily as more complex, nonverbal forms are presented. The verbal nonsense syllables' material is the most difficult. The reason for this difficulty is probably because the learner must try to form some concept of verbal relationship which is not necessary in the simple verbal color word tests.

Evidently there are differences inherent in the material used for testing academic and non-verbal learning. This difference would indicate that concrete and specific material is easier to grasp as compared with verbal and that learning becomes more and more difficult as the material becomes less specific and more concrete in the non-verbal field and approaches the easy verbal material.

Meumann and others have shown that types of ideation, both concrete and verbal, exist in modalities of vision, audition, and tactual-motor, etc. Visual, auditory, and motor types are common concepts in describing eye-minded, ear-minded, and motor-minded pupils. Would it not be possible, since the above is true, to find different types yet undifferentiated and unrecognized in the power of imagery in one modality? For example, in the visual field, would different kinds of visual imagery explain these individual variations? It is not apparent which casual hypothesis best fits the results of this study. Further research of a subjective character will have to be done before casual factors can be determined.

RESULTS AND CONCLUSIONS

1. Qualitatively different patterns of a similar and familiar nature yield quantitatively different results to the same individual in terms of his learning performance. On some tests these results are statistically significant and large.

2. These differences might be due to qualitative aspects inherent in the symbol combinations as they come in contact with the neural process of the learner in the visual field.

3. The imaginal types of learners in the visual field might be a factor in individual variations on similar learning tests.

4. Non-verbal forms, as here indicated, in general are learned more easily than verbal. These differences increase as the verbal content becomes less concrete or less specific.

5. Specific concrete material, both verbal and non-verbal, can be grasped more readily by the learner.*

LITERATURE CITED

1. Garrett, H. E. Statistics in Psychology and Education, New York, Longmans, 1938
2. Meumann, E. The Psychology of Learning, New York, Appleton, 1913

*I am indebted to Dr. Robert Brotemarkle of the University of Pennsylvania for valuable suggestions in this study.

The Effect of College Entrance Delay on College Grades

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INTRODUCTION

This is a study of the effect of college entrance delay on college grades. The main objective of the study was to find something of value for guidance of exceptionally young high school graduates or of others who for any reason contemplate delay in entering college.

PROCEDURE

The members of the experimental group are male graduates of Kansas State College who entered the college as freshmen during the years 1924-1931 inclusive, one year after high school graduation. All members of the group who could be matched were included. The number used for the experimental group was 103.

With each member of the experimental group was matched a male student of the same age at high school graduation who had approximately the same high school grades and freshman test score, was from the same high school or a high school of equal size and distance from the college and who went immediately to college after high school graduation.

For members of the second control group, each member of the experimental group was matched with a male student of the same age at college entrance, who had approximately the same high school grades and freshman test score, was from the same high school or a high school of equal size and distance from the college and who went immediately to college.

Grades for the first two years of college are used as a criterion of college success in the present study.

College marks and control factors for all groups were obtained from the Registrar's office and psychology office of Kansas State College.

To facilitate comparisons the results of this study are stated in terms of standard scores.

TABLE I. Gains and reliability of gains in performance of groups

	Group	Gain	S.D. gain	C.R.
E	Mx_3–Mx_1	.360(+)	.253	1.42
E	Mx_3–Mx_2	.359(—)	.205	1.75
C_1	Mx_3–Mx_1	.553(—)	.192	2.88
C_1	Mx_3–Mx_2	.641(—)	.210	3.05
C_2	Mx_3–Mx_1	.757(—)	.217	3.48
C_2	Mx_3–Mx_2	.738(—)	.192	3.84

E = Experimental group
C_1 = Control group number one
C_2 = Control group number two
Mx_1 = Mean of high school grades
Mx_2 = Mean of freshman test scores
Mx_3 = Mean of college grades

For convenience of expression and calculation the differences found have been stated in terms of gains. These gains may be either positive or negative. The reader will observe that the first line E of Table I shows the gain of

mean college grades over mean high school grades to be .360+; that is, a positive gain of .360; standard deviation of gain .253, and critical ratio .142 for the experimental group.

The second line E shows the gain of mean college grades over freshman test scores of .359—; that is, a negative gain, really a loss of .359; standard deviation of gain .205 and critical ratio 1.75 for the experimental group.

The succeeding lines of Table I should be interpreted similarly for Group C_1 and C_2.

The final results were expressed in the form of differences in gains and reliability of differences in gains for Group E and Croup C_1; and for Group E and Group C_2.

The gain of Group E in college grades compared with high school grades was .913 greater than the comparable gain of Group C_1. The standard deviation of this difference was .318; critical ratio 2.87.

The gain of Group E in college grades compared with high school grades was 1.117 greater than the comparable gain of Group C_2. The standard deviation of this difference was .313; critical ration 3.57.

The gain of Group C_1 in college grades compared with high school grades was .204 greater than the comparable gain of Group C_2. The standard deviation of this difference was .265; critical ratio .770.

The gain of Group E in college grades compared with freshman test scores was .282 greater than the comparable gain of Group C_1. The standard deviation of this difference was .293; critical ratio .96.

The gain of Group E in college grades compared with freshman test scores was .379 greater than the comparable gain of Group C_2. The standard deviation of this difference was .281; critical ratio 1.35.

The gain of Group C_1 in college grades compared with freshman test scores was .097 greater than the comparable gain of Group C_2. The standard deviation of this difference was .285; critical ratio .340.

SUMMARY

This is a study of the effect of college entrance delay on college grades.

The aim was to find something of value for guidance of high school graduates who are exceptionally young or who for other reasons contemplate delay in entering college.

Grades received during the first two years in college by students who entered one year after high school graduation were no lower than those received by students who entered college immediately after high school graduation.

Grades earned during the first two years in college by students who entered college one year after high school graduation were significantly superior to those earned during the same period by one group of students who entered college immediately after high school graduation and also superior to those of the other control group, but not significantly so.

It may safely be said that nothing in this study shows a detrimental effect on college grades from one year's delay in college entrance after high school graduation.

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An Experimental Investigation Into the Life History of Blatticola Blattae, a Nematode Found in Blattella Germanica

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The taxonomy of nematodes infesting insects of the family Blattidae has been worked on for many years by various investigators. But to the writer's knowledge there has been only one study made on the life history of a nematode found in the Blattidae. Although *Hammerschmidtiella diesingi* was included in the aforementioned study, special emphasis was placed on *Leidynema appendiculata*. Both of the worms were found in *Periplaneta americana*. Thus its was felt that a study of the life history of *Blatticola blattae*, which is found in *Blattella germanica*, would be interesting as well as informative.

CHARACTERISTICS OF *BLATTICOLA*

The mouth is surrounded by eight submedian papillae. The esophagus consists of a club-shaped anterior part and a posterior muscular bulb. The intestine is much dilated at its anterior end. The vulva is situated at the posterior end of the body, and the ovary is single. The egg is oval. Both male and female possess conical tails. There are two pairs of preanal papillae and two pairs of postanal papillae on the male. The male possesses a single spicule. The male averages 880 μ in length and 60 μ wide. The females are usually about 2 mm. in length and average 130 μ in width. (Plate I, Figs. A, B, and C).

MATERIALS AND METHODS

The roaches used in this study were collected at the animal house on the campus of the University of Kansas.

Three physiological salt solutions were used as media: 1) 0.85 N saline solution; 2) Hobson's fluid for insect tissue; and 3) Ringer's solution. Tap and distilled water were also used; in these liquids the worms developed normally.

The roaches were dissected alive in one of the media. After a thorough examination of the body cavity of several roaches, it was soon discerned that no worms penetrated the intestinal wall. The intestine was systematically dissected and it was early observed that worms were never found in the stomach or upper intestine. They were consistently found in the large intestine in the region of the Malpighian tubules.

Most of the worms were studied in the unstained condition; however some of them were fixed in A. F. A. Nematode Fixative and stained in aceto-carmine. The unstained worms were very easy to study because of the transparency of the cuticle. In general, the best results in staining were obtained by overstaining and then destaining in acid alcohol. None of the eggs were fixed or stained, because the egg shell was very transparent.

Some difficulty was encountered in the rearing of uninfected roaches.

Blattella germanica, unlike *Periplaneta americana,* does not deposit its oötheca before the young are hatched. It was found, however, that if the oötheca of *Blattella* was detached at a certain time, the young would hatch. The time of detachment was indicated by the appearance of a dark "line" on the ventral surface of the oötheca. After the oötheca was detached, it took from thirty minutes to five days for the roaches to hatch. This variation was constant. The amount of time required for the roaches to reach adulthood was about four months. Younger roaches as well as adults were used for feeding experiments.

THE CULTURING OF *BLATTICOLA* EGGS AND THEIR EMBRYONIC DEVELOPMENT

The female *Blatticola* is oviparous as are the majority of parasitic nematodes. When exposed to the air in a physiological saline solution, the worms began to deposit their eggs immediately. The rate of deposition, although varied, took place as fast as one egg every 3-5 seconds. Some of the worms emptied the uterus in two or three hours, but in practically every case the uterus was emptied when the worms were left over night in a culture medium.

To prevent drying the eggs were kept in a culture medium in a moist chamber on hollow ground slides. It was observed that eggs placed under cover slips on hollow ground slides continued development but at a decreased rate. Thus the eggs seemed to be able to survive when the supply of oxygen was limited. If the eggs were subjected to a temperature of 5 degrees C., development ceased; but if the temperature was raised only a few degrees, the eggs developed normally, even at a temperature of 39 degrees C.

As a general rule the majority of the eggs when eliminated by the worm were in the four cell stage. The cleavage of the egg is total but unequal. The four cell stage assumed a rhombic shape as in *Ascaris.* (Figs. B′ and C′) Development was observed from the two cell stage to the "resting" embryonic stage. After 24 hours the prevermiform stage was reached (Fig D′). In this stage the distinction of the individual cells of the embryo in the unstained condition was lost under the high power of the microscope. 37½ hours later the active embryonic stage was reached. This stage was characterized by the noticeable development of the esophagus and the lashing of the tail back and forth (Fig. E′). 10 hours later the embryos became gradually inactive and began to molt; at least the behavior was so interpreted.*

5 hours after activity had ceased and the process of molting was complete, the "resting" embryonic stage was reached (Fig. F′). In this stage the embryo was much shorter than in the active stage, and the esophagus was better developed. In vitro development stopped at this point. It has been reported by Todd (1941) that the eggs of *Leidynema appendiculata* would hatch in vitro if the infective eggs were treated with certain dilute protein solutions. Possibly such might be the case with the eggs of *Blatticola.*

POSTEMBRYONIC DEVELOPMENT OF *BLATTICOLA*

In order to find out whether or not the transmission of the worm was direct from roach to roach and to find out what stage of the embryo is

*The author feels that much more study is needed to clear up the question of molting and the number of molts.

ADULT MALE AND FEMALE *BLATTICOLA* AND FEMALE REPRODUCTIVE SYSTEM

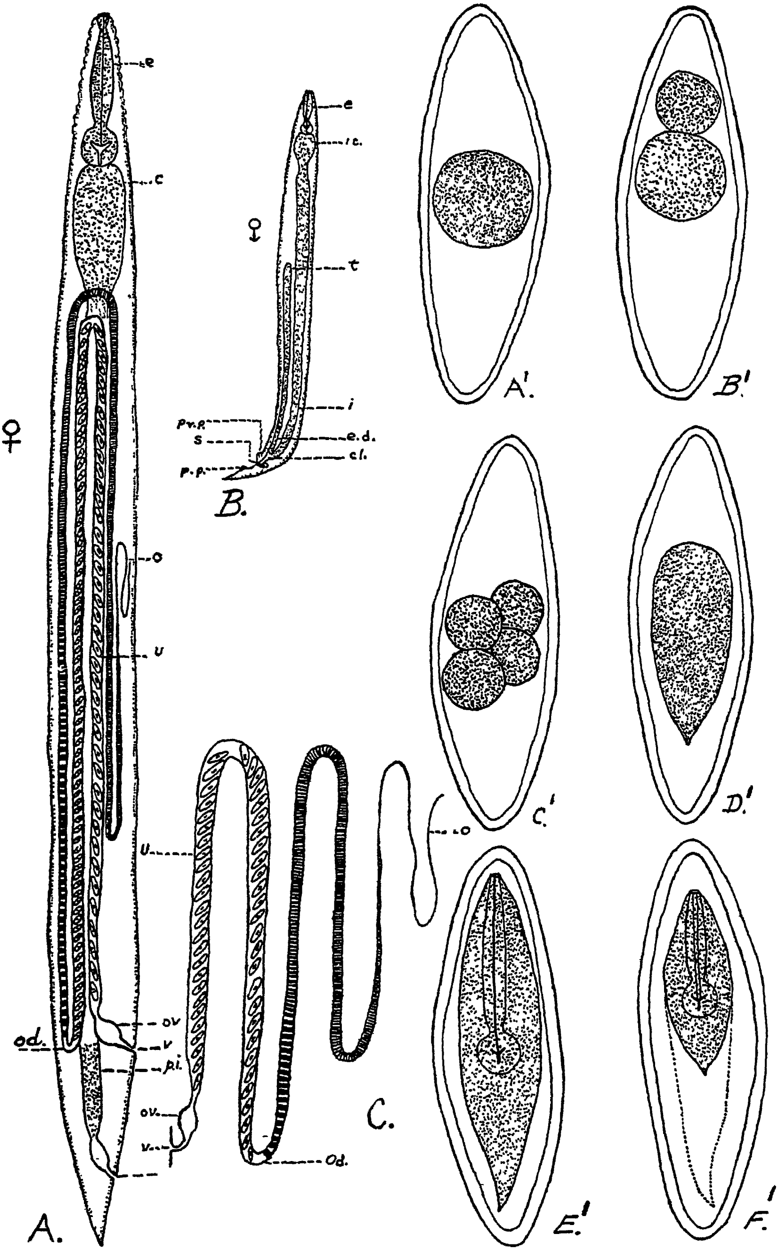
A. Female
- a. anus
- e. esophagus
- i.c. intestinal cardia
- o. ovary
- od. oviduct
- ov. ovejector
- p.i. posterior intestine
- u. uterus
- v. vulva

B. Male
- cl. cloaca
- e. esophagus
- e.d. ejaculatory duct
- i. intestine
- i.c. intestinal cardia
- p.p. post-anal papilla
- pr. p. pre-anal papilla
- s. spicule
- t. testis

C. Female reproductive system
- o. ovary
- od. oviduct
- u. uterus
- v. vulva

EMBRYONIC STAGES OF *BLATTICOLA*

- A'.1 1 cell stage
- B'. 2 cell stage
- C'. 4 cell stage
- D'. Prevermiform stage
- E'. Active stage
- F'. Inactive stage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infective, it was necessary to carry out some feeding experiments. The eggs were fed to uninfected roaches in their food and drink.

Experiment A: Eggs in all stages of development, but with the majority in the "resting" stage, were fed to a roach. When dissected four days later, four larval worms were found in the large intestine of the roach.

Experiment B: Eggs in the "resting" stage exclusively were fed to four roaches. Two days after feeding, three of the roaches were dissected. In one roach, one worm was found, in another six worms were found. Three days after feeding the fourth roach was dissected; however no worms were found.

Experiment C: Eggs in the active embryonic stage were fed to an uninfected roach. A few hours later active embryos were fed the same roach again. Two days later more active embryos were fed the same roach. The roach was placed with the active embryos for a limited time only. This action prevented the active embryos from becoming "resting" stages, and thus to have a chance to infect the roach. Two and one-half days after the last feeding the roach was dissected, but no worms were found. It was noted that the active embryos that were ingested did not infect the roach. Thus the conclusion was reached that the eggs must reach the "resting" stage before entering the roach's intestine in order to be infective.

The eggs of *Blatticola* hatched directly into larvae resembling the adults. The principal changes which the larvae undergo are the development of the mouth region and the reproductive system. It was proven by dissection that the eggs hatched in the roach's intestine 24 hours after feeding; whether or not they hatched earlier was not learned. Many larvae in various stages of development were observed in cultures and in the roach's intestine. The average amount of time required for the embryos to reach the "resting" stage was three and one-half days. The exact amount of time required for the newly hatched larvae to become mature was not accurately ascertained.

THE INCIDENCE OF INFESTATION AND HOST PARASITE RELATIONSHIP

A total of 208 roaches were dissected. Of this number 108 were female, 62 males, 14 immature, and 24 were of undetermined sex. The following tables summarize the number of worms found per roach and the percentage of parasitized roaches, as well as their distribution according to sex and maturity.

A. INFESTATION OF ROACHES
(Sex not determined)

I. Variation in the number of worms found per roach.	
a. Sex not determined	0–4
b. Males	0–2
c. Females	0–4
II. Average number of worms found per roach.	
a. Sex not determined	1.5
b. Males	.7
c. Females	.8
III. Percentage of roaches infested.	
a. Sex of worm not determined	93.3
b. With male worms	71.0
c. With female worms	64.3

B. INFESTATION OF MALE ROACHES

I. Variation in the number of worms found per roach.	
a. Sex not determined	0–2
b. Males	0–1
c. Females	0–1
II. Average number of worms found per roach.	
a. Sex not determined	1.08
b. Males	.64
c. Females	.58
III. Percentage of roaches infested.	
a. Sex of worms not determined	79.3
b. With male worms	75.8
c. With female worms	58.1

C. INFESTATION OF FEMALE ROACHES

I. Variation in the number of worms found per roach.	
a. Sex not determined	0–4
b. Males	0–2
c. Females	0–4
II. Average number of worms found per roach.	
a. Sex not determined	1.46
b. Males	0.69
c. Females	0.80
III. Percentage of roaches infested.	
a. Sex of worms not determined	89.8
b. With male worms	72.2
c. With female worms	70.4

D. INFESTATION OF IMMATURE ROACHES.

I. Variation in the number of worms found per roach.	
a. Sex not determined	0–3
b. Males	0–1
c. Females	0–2
II. Average number of worms found per roach.	
a. Sex not determined	1.28
b. Males	.64
c. Females	.64
III. Percentage of roaches infested.	
a. Sex of worms not determined	85.7
b. With male worms	64.3
c. With female worms	50.0

E. A Comparison of the Incidence of *Blatticola* in Male, Female, and Immature Roaches.

	Variation in number of worms.	Average number of worms.	Percentage of Infestation
Male Roaches	0–2	1.08	79.3
Immature Roaches	0–5	1.28	85.7
Female Roaches	0–4	1.48	89.8

Most of the roaches were dissected as soon after capture as possible. However, the number of worms found per roach in roaches kept for some time was about the same as that in roaches dissected immediately after capture. Since one large female *Blatticola* could occlude the contracted large intestine of *Blattella,* it was not surprising that the number of worms found was small. The female worm orientated herself in the roach's intestine in such a way that her anterior region was always directed toward the small intestine. Female

roaches have been dissected in the greatest numbers due to the fact that they were much easier to work with. Thus, in interpreting these figures, one must keep in mind the small number of specimens dissected. It was noted, however, that the figures for a much smaller group of roaches correlated positively with the figures presented in this paper.

As already pointed out the size of infestation was quite low. It was noted that none of the vital activities of the roaches was hampered by the presence of the worms. Infested roaches which were in captivity for six months reproduced with the same facility as uninfected roaches.

SUMMARY

Blatticola blattae occurs in the large intestine of *Blattella germanica* in very small numbers; never more than four worms per roach. In this series of roaches the percentage of roaches infested and the number of worms found per roach were in the following order: Females the highest, immature roaches the next highest, and males the least. The cuticle of the worm and the egg shell were both very transparent, thus the study of unstained specimens was found to be very satisfactory and even preferable. Cleavage of the nematode egg was total but unequal. The embryos developed as far as the "resting" stage in vitro. The rearing of uninfected roaches was complicated by the fact that the oöthecae of the roaches were not detached from the female before the young were hatched. It was learned that the active stage of the worm embryo was not infective; however, the "resting" stage was infective. The presence of the worms seemed to have no effect on the vital activities of the roach.

LITERATURE CITED

1. Ackert, J. E. and Dobrovolny, C. G. The life history of *Leidynema appendiculata* (Leidy), a nematode of cockroaches. Parasitology, 26: 468-480 1934
2. Chitwood, B. G. A synopsis of the families of nematode parasites of the family Blattidae. Zeitschrift für Parasitenkunde, 5: 14-50 1932-33
3. Todd, A. C. An addition to the life history of *Leidynema appendiculata* (Leidy, 1850) Chitwood, 1932, a nematode in Cockroaches. Journal of Parasitology, 27:34 1941

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Propagation of the Spotted Channel Catfish (Ictalurus Lacustrus Punctatus)

LEO BROWN, Kansas State Fish Hatchery, Pratt, Kansas

The spotted channel catfish has long been held in high esteem as a sporting fish by the Kansas angler. It is equally popular as a pan fish.

The first attempts to raise this fish artificially were made at the State Fish Hatchery, Pratt, Kansas, in 1925. Several years later the Oklahoma, Texas, and Missouri game commissions likewise undertook, with considerable success, the artificial propagation of this species.

The first attempts at Pratt were made upon eggs collected from a submerged boat sunk in a farm pond in Kingman County, Kansas; the eggs were later brought to the State Hatchery for incubation. This first attempt was not very successful. The importance of fanning the eggs, to keep off silt and sediment, the need of forcing water through the eggs, to prevent mold formation, and proper methods of handling eggs and fry were matters that required several years of experience to learn. This paper reports the results of these experiences gained at the Pratt State Hatchery.

Spotted channel catfish in its native habitat is a dweller of our larger streams and rivers. They are active most of the year, but in mid-winter they bunch up and do not move around to any extent. When the channel catfish is brought to hatchery ponds its native surroundings are left behind. Instead of rocks, tree trunks, roots, and holes in the streams for nesting and resting, the brood ponds at the hatchery are barren except for three or four nail kegs. The swift streams and riffles, with their abundance of insect life, are also missing. The first year the adults are moved to hatchery ponds, spawning is very light or no eggs are taken at all. The second year, normal egg production is accomplished. Normal production may be defined as the production of the adults at the hatchery ponds after they have become acclimated to the new surroundings.

Adults are sexed in March or April and four to six pairs are stocked to each pond. They range in size from one and one-half to ten pounds. Occasionally some of the larger ones will reach twelve or fifteen pounds. The channel catfish spawn at the age of three years, but better results are gained at the fourth and fifth year.

Spawning takes place in kegs supplied for the purpose. Three or four kegs in each pond are staked down at a depth of about two feet under water to keep them from floating. The open end of the keg is placed toward open water, but they can be placed at any side of the pond. For convenience of collecting the spawn, the kegs are placed about six to ten feet apart.

If the water is clear the male and female may be observed striking and circling around the kegs. The male fish is the master of ceremonies, first preparing the nest by cleaning the keg of silt and dirt. After the debris is

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cleaned from the keg, a mucus secretion is liberated on the lower inner surface of the keg, making a very smooth, waxy appearing surface.

A female is selected by the male and lured into the keg. If the female refuses to go into the keg, she is many times treated roughly until she is persuaded into the nest. Battles of males for favorite nesting kegs and favorite females also may cause injuries, sometimes resulting in death.

Spawning takes place in the day time from 8 a.m. to 6 p.m. and usually is completed in from one to three hours. The male and female may be in the kegs head first or tail first while the eggs are being ejected. Usually they are headed in the same direction, the vents close together and their bodies slightly tilted outwardly. If disturbed before spawning is complete, the fish will return immediately and complete the process.

After spawning is completed, the female leaves the nest, either willingly, or by force of the male fish. At no time has the male ever been observed to leave the nest unless disturbed. He remains over the eggs continually fanning them with the caudal and anal fins to clean them of sediment.

Cannibalism is sometimes practiced by the male fish, who devours the eggs and deserts the nest. For the past three years, seventeen per cent of the spawn have been eaten by the males. It is not known why the male fish eats spawn but many eggs can be saved by collecting the spawn and hatching them in an incubator artificially.

It was believed that, for the most part, the spawning impulse was governed by the temperature of the water. After five years of recording water and air temperatures, it was found that cool weather slows down spawning for a few days. If it remains cool for some time, as it was in 1941, the fish spawn, regardless of the continued coolness. If, after a cool snap, warm weather follows, spawning is abundant for the first two days and then goes back to the normal rate. In the past five years, the first spawn of the season was collected between May 29 and June 3. This observation indicates that illumination, as well as temperature, may play a part in the spawning impulse.

Females spawn but once a year and from all observation they have but one male. However, a male may take care of one or more females a season, but he never has more than one female at a time.

The size and number of eggs depends upon the size of the females. The first year, spawn is small and the eggs are smaller in size than those of females that have spawned for two or more seasons. The spawn from a female ranges from one-third of a pound up to six and one-half pounds. The six and one-half pound spawn is the largest ever to be collected at the Kansas Hatchery. The average spawn ranges from one to two and one-half pounds.

The eggs in appearance resemble small, gelatinous pearls, adhering together and looking much like tapioca. They are yellow in color. As they approach the hatching stage, the eggs turn from a yellow to a brownish yellow-moving mass. Eggs that are not fertile appear pale yellow to white in color and are slightly larger than fertilized eggs. The egg membrane of unfertilized eggs is not elastic and is more easily broken than fertile eggs, which makes them easy to remove without injuring the fertile eggs. Eggs number from 450 to 500 eggs per ounce or around 8000 eggs per pound.

Nail kegs are visited every other day and the eggs are taken from the nest to an incubator to complete their hatching. The incubator is a wooden trough

made from two by twelve boards twelve feet long. Five paddles are used with each incubator, the paddles being attached to rocker arms operated by a pitman which, in turn, is operated by a small water wheel.

The eggs are placed on screen racks in the incubators under the paddles. The purpose of the paddles is to replace the fanning process conducted by the male fish to remove sediment from the eggs.

The eggs hatch in from six to ten days, depending upon the temperature of the water. When the temperature ranges from sixty to sixty-five degrees Fahrenheit, the eggs hatch in nine or ten days. As the temperature reaches seventy-seven degrees or higher the eggs hatch in five or six days. The eggs fail to develop at temperatures that remain below sixty degrees. Molds cause much loss to eggs that are kept at temperatures of ninety degrees or more. It is also necessary to candle out spoiled eggs from three to five times daily. If the spoiled eggs are not removed the eggs touching them may spoil. In some cases where the eggs were not removed, the entire spawn was destroyed.

Soon after the eggs hatch, the fry are siphoned from the incubator and placed in wooden troughs. Water is kept running through the trough to supply the fry with oxygen. The fry live on the egg yolk for the first four to six days, depending upon the temperature of the water. After the egg yolk is absorbed, the fry come to the surface of the water in search of food. They are fed from three to five days on dried buttermilk or egg meal. The fry are then moved out into ponds where they remain until fall. Sixty to one hundred thousand fry are placed in a pond. The fry are fed once a day on dried buttermilk and ground carp mixed in equal proportions. The past year carp was hard to get in sufficient quantities and meat scrap was used with dried buttermilk. This mixture proved very satisfactory. The fish raised the past year were the healthiest fingerlings that have been produced in the past five years, and ranged from four to six inches in length.

At the end of the first year, some fingerlings are stocked in new water throughout Kansas; others are held over and fed for the second season and stocked out in old waters. The second-year channel catfish ranges from seven to fourteen inches in length and is capable of competing against other varieties of fish found in lakes and streams. The yearlings, when stocked in old waters, are largely wasted and merely furnish food for other species of fish already in the waters. Abount ninety-five per cent of the two-year-old channel catfish survive, but only ten per cent of the first year channels stocked in old waters have been found to survive.

Crayfish are the main diet for the adult channel catfish. The surplus of crayfish taken from the hatchery ponds at fishing time are collected and placed in the ponds that contain the adult catfish.

Animals that prey upon the young catfish are varied. A stray bass or so in a catfish pond may consume a number of them, and in some cases forty or fifty bass may devour the entire catfish population in a pond by fall.

The water snake belonging to the genus Natrix catch a great number of fish annually at the hatchery. Water snakes have been observed catching a fourteen inch catfish. Many snakes have been killed that have contained from nine to as high as twenty-one of the six-inch catfish in their stomachs.

As many as 161 water snakes have been killed in one day around the hatchery ponds.

Bitterns, herons, mergansers, and pied-billed grebes do some damage to fish populations, but are not abundant enough to be of much importance. Birds are easily frightened away and are an easy target if they become too destructive.

Turtles are abundant and do some damage to fish production. They do not catch many fish but are a menace in that they eat food that is intended for the channel cats.

Fingerling catfish are free from most diseases if handled scientifically. The two-year catfish are exceptionally free from disease; the greatest losses come from predators. A protozoan disease called ichthyophthirus is about the only malady of importance that attacks the first year catfish. This disease is caused by a skin-inhabiting parasite commonly found on warm water pond fish. The parasites are easily seen in the skin of infected fish, appearing as small white bumps, and vary in size from microscopic forms to that of a large pin head. The most effective treatment is to change the feeding ground by raising or lowering the water level. These protozoa must have fish life present in order to survive and without fish life will live but a few hours. By changing the feeding grounds the protozoa soon die and many fish escape without taking the disease. The disease usually occurs in the late summer or early fall. If one does not detect the disease until most of the fish are infected, the entire stock in a pond may be lost. It is good practice to raise and lower water levels and shift the feeding grounds to prevent the disease from ever breaking out.

The young channel catfish are nervous in nature and dart away quickly at any unusual sound. It has been noticed that the movement of trucks in feeding invariably causes a disturbance and many times the fish do not come in and feed until the truck has moved on. An accompanying car, with the one used daily, usually disturbs them and they feed but little, or, in some instances, do not feed until the cars have gone. A stranger riding with the employees in the truck that is used daily also disturbs the fish from feeding.

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Notes on Animal Occurrence and Activity in the White Sands National Monument, New Mexico[1]

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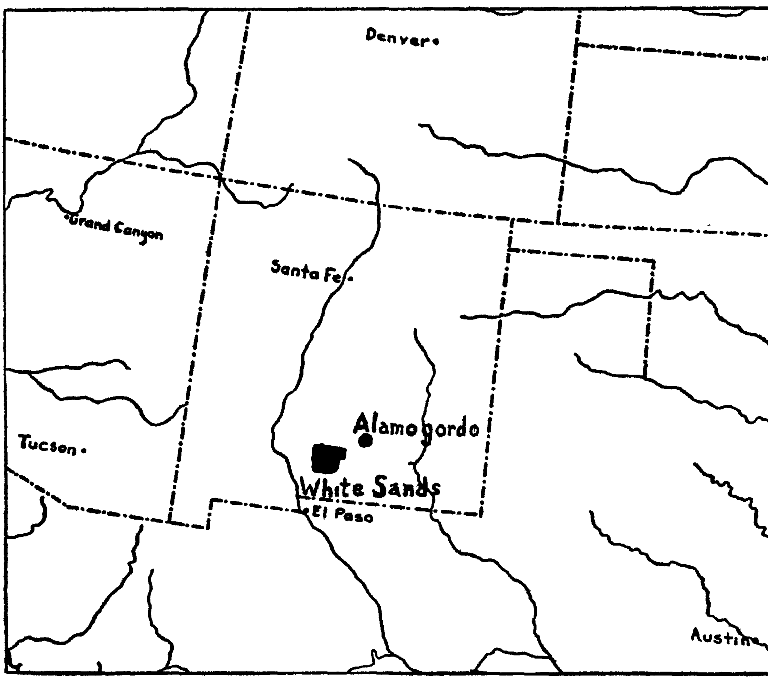
The White Sands National Monument is a unique area which consists of some 274 square miles of white gypsum sand, piled up at some points into dunes sixty feet high. It is located in the southern part of the Tularosa basin, west of Alamagordo, New Mexico. (See map).



MAP No. 1
Location of the White Sands National Monument, New Mexico.

An excellent account of the flora of the Sands is given by Emerson (1935) in which he points out many interesting facts concerning the fight of plants for existence in the moving dunes and questions are raised as to how they obtain nitrogen, as only a minute amount is found in the sands.

Several authors (Ruthven, 1907; Dice, 1930; Benson, 1933; etc.) have listed the vertebrate animals found in the White Sands and Benson discusses the

[1]Contribution No. 39 from the Department of Zoology of Fort Hays Kansas State College.

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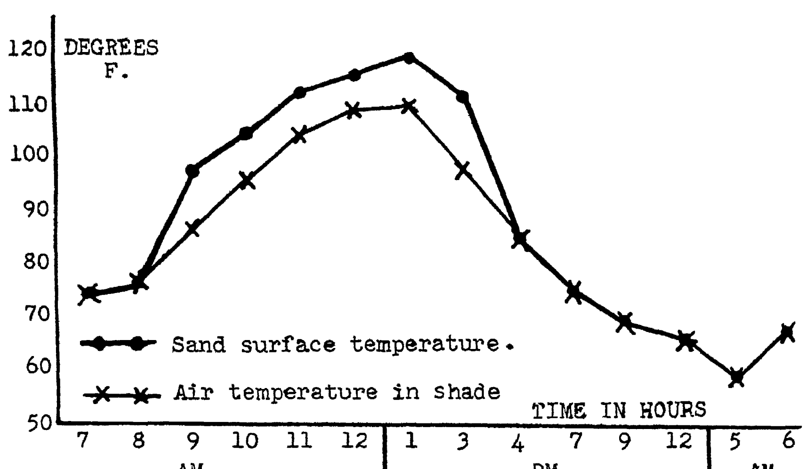
vertebrates from the standpoint of their concealing coloration and its evolutionary significance. This coloration is an interesting feature because several species of rodents, most prominent of which is *Perognathus apache gypsi,* a pocket mouse, and a lizard (*Holbrookia maculata* subspecies) display light colored races within the boundaries of the Sands.

In reviewing the literature it was found that there were few records of invertebrate fauna of the White Sands. This paper, therefore, records a few observations of behavior of some vertebrates and invertebrates as noticed on two overnight trips to the Sands during the summers of 1940 and 1941, while the author was teaching on the summer faculty of New Mexico Highlands University at Las Vegas.

PHYSICAL CONDITIONS

Because of the low average rainfall (7 inches) the White Sands is classed as desert. It is surrounded on the north, east and south by a desert of quartz sand and on the west by the San Andreas mountains. It has been pointed out by other investigators (Chapman and others, 1926 and Buxton, 1923) that temperature varies widely on sandy desert areas, and that the activity of animals can often be correlated with these changes. The observations which follow agree with the above. The following graph (No. 1) illustrates the temperature range in the Sands over a 24 hour period. One thermometer was hung in the shade and another was placed directly on the sand at the base of a northeast facing dune. From a low of 58 degrees F. at 5 a.m. both on the sand surface and in the air the temperature climbed to a high of 118 degrees F. on the sand and 109 degrees F. in the air at 1 p.m. By 3 p.m. it had become cloudy and at 4:30 it sprinkled very lightly for a few minutes when the temperature of the sand surface and air again became the same (82 degrees F.). Hot, cloudless days are vouched for by others when probably a greater range in temperature occurs.



GRAPH NO. 1
Range of temperature over a twenty-four hour period in the White Sands, New Mexico.

The top of the water table, on the flats between the dunes, is never more than two or three feet below the surface. One can dig a hole three feet deep and have a steady supply of water for washing purposes and drinking also, if the bitter taste can be stomached. Thus, water for plant growth is plentiful, although it is heavily impregnated with calcium sulphate. Upon the dunes, of course, little water is available so that the plants which grow there must send long roots down to the water table.

The fine sand blows when the wind attains enough velocity and as a result dunes are continually shifting. The prevailing wind is from the southwest. As the dunes advance plants growing in the flats become covered and die. Seven, of the sixty-seven species of plants within the Sands, however, have been found (Emerson, 1935) that can grow fast enough to keep their heads above the advancing sand.

ANIMAL OBSERVATIONS

No attempt has been made to identify all of the species observed. In some cases they have been keyed out to families or genera by the author and a few have been determined by specialists, to whom credit is given in the text.

As Chapman (1931, page 376) points out, "The population on the sand at night was entirely different from that of the daytime." A discussion of the various species observed is given under the general titles of "Day and Night Prowlers."

Day Prowlers

Sceloporus species—This brown-colored swift occurred in the flats between the dunes and was found in the open spaces among the plants during the morning and late afternoon hours. In the heat of the day they sought refuge in the shade of the more bushy plants. At this time they were easily caught when several persons would surround the bush. At no time were those in the Sands or those kept in captivity in boxes with white sand covering the bottom, observed to enter burrows of other animals or dig into the sand themselves.

Holbrookia species—The famous white lizard of the Sands shades from white, through pink to greyish forms. Its habits seem to be much like the one above. Often individuals of this species could be found under the same bushes with the brown swift during the heat of the day. Several kept in captivity in a box containing white sand were observed to dig into the sand although not to the extent as the next species. Often they barely covered their bodies allowing the head to remain free or at least the eyes exposed.

Cnemidophorus species—This pretty blue race-runner seemed to prefer the faces of the dunes rather than the flats during their active periods. Specimens were noticed in the morning, but disappeared as the heat of the midday approached. They were not found under the bushes and for some time their retreats were a mystery. Upon digging up a burrow in a flat, which was thought to be made by a species of gopher (Possibly *Geomys arenarius brevirostris*), a race runner suddenly darted out of the tunnel. This individual was the only one we succeeded in catching. There were many such burrows, about 3 or 4 inches below the surface of the sand, running for many feet from bush to bush. The race runner when placed in a box containing white sand immediately dug a tunnel deep into the sand. It is doubtful if the race runner digs such long tunnels, and he may use the gopher holes as re-

treats; but his action in the box suggests that he may burrow in himself if need be and much deeper than the white lizard.

All the specimens of lizards fed well on medium to small insects offered them in captivity. None were observed on the sand during the night.

Arthropoda

Coleoptera—There are several species of Darkling beetles in the Sands. Their dark color stands out in glaring contrast to the white background. They are encountered trudging about chiefly on the dunes, where the trails that they leave can be seen leading off in all directions. They have been observed actively foraging during the morning and late afternoon hours. At no time were they observed to dig into the sand; three specimens kept in captivity for several weeks remained always on the surface. It is possible that they also forage at night, as the sand in the morning is a maze of tracks, many of which appeared to resemble those made by the beetles. However, tracks made by the white cricket, which forages at night, are almost identical with those of the beetles. None of the species appeared to be confined to the White Sands. They are predaceous insects so they must live off of other insect-life of the Sands.

Curculionidae—A species of snout beetle was often picked up on the sand or collected on the low growing shrubs in the flats. Many of these were white, although several black specimens were found that appeared to be identical with the white forms except for the difference in color. The white form is not restricted to the Sands. It must live on the plants scattered about over the flats and toward the edges of the Sands.

Coccinellidae—Several specimens of a lady-beetle were seen on the sand both during the day and night but were active only during the day.

Hemiptera, Pentatomidae—Several species were observed on the sand and about the shrubs.

Homoptera, Cicadidae—In the shrubs, especially a species of *Rhus*, the shrill cadence of a medium sized cicada could be heard continually during the warmer parts of the day. Often they would flush out as we walked among the plants and settle down on another bush further on.

Jassoidea—Leaf-hoppers were quite abundant wherever there was a growth of plants.

Orthoptera, Acrididae—Grasshoppers were found sparingly within the Sands, even in areas where no plants occurred. This occurrence raises a question as to what food they could secure in such plant-less areas.

Lepidoptera, Pieridae—Several species of sulphurs were observed about the flowers of the yucca and an endemic verbena.

Tineoidea—The Pronuba moth was numerous about the yucca.

Hymenoptera, Formicidae—At the east base of a dune, some distance from any plants, was found a mound of a species of harvester or mound-building ant (See cut). The mound consisted of dark-reddish particles intermixed with the white sand. Later it was learned that the reddish material was from some clayey dirt once used as the basis for a road-bed in the Sands. Apparently the ants must travel some distance to reach the nearest plants. They were very active during the day with the exception of the warmest hours of midday when only a few could be observed around the openings of the nest.

Eurytomidae—At least two species of chalcid wasps belonging to the family *Eurytomidae* were found emerging from the seed capsules of a mint

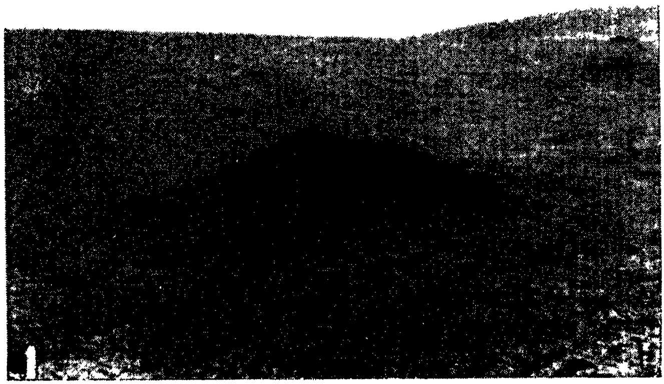


FIG. 1.
Nest of a Mound-building Ant Species in the heart of the White Sands National Monument.

(*Poliomintha incana*).* One species belongs to the genus *Rileya* and the other to the genus *Decatomidea.* They were active throughout the day.

Diptera, Asilidae—Many species of Diptera occur in the Sands but robber-flies are especially numerous. They were active during the greater portion of the day and rested among the bushes during midday.

Many insects were found dead on the sand during the day. This mortality may have been due to the heat. Chapman and others (1931, page 377) state that on quartz sand dunes in Minnesota, most insects dig into the sand or retreat to shade when the temperature nears 50 degrees C. Certain it is that during the middle of the day insect activity in the Sands is greatly reduced but further observation is needed to determine the maximum temperature that must be approached before retreats into the sand or shade is sought by the greatest number.

NIGHT PROWLERS

Insecta

Coleoptera, Cicindelidae (*Cicindela lepida* Dej?)—A species of light-colored tiger beetle was found in considerable numbers along the crests and to a lesser degree on the windward slopes of the dunes at night. The beetles observed were strongly positively phototropic and would come running from all directions towards a flashlight placed on the sand. The elytra are light colored with small brownish to bronze chevrons. The head and thorax are a bronzy irridescent color. None were seen during the day and although they were not actually observed to do so, it is believed that they dig into the sand during the day.

On checking the species of tiger beetles in "Coleoptera or Beetles of Indiana"

*Identified by F. W. Emerson.

by W. S. Blatchley (1910), the specimens from the White Sands seemed to fit very well the description of *Cicindela lepida* Dej. Batchley states (pages 35-36) that *Cicindela lepida* has been taken in Indiana on the bare white sand along the beach of Lake Michigan. He adds further that it is said to fly to electric lights. The "bare white sand" habitat would correspond to the White Sands and its attraction to electric lights suggests that in Indiana, as in New Mexico, it is a night forager. This behavior is quite different from other species of the genus *Cicindela* which are normally diurnal foragers.

Orthoptera, Stenopelmatidae—A species† of white cricket was encountered on the windward slopes of the dunes at night only. This species is entirely white and the light color must be due to a lack of any pigment as one can see through the epidermis and observe internal organs. It did not seem to be either positively or negatively phototropic as one continued to gnaw on a kernal of wheat in the light of a flashlight. Specimens have also been observed on the dunes on bright moonlight nights when a flashlight was not necessary to find them. This behavior might suggest that temperature, rather than light, or a combination of both, governs their behavior because during the day they dig down into the sand. Several captive specimens always dug rapidly into the sand when they were dug up. They seem to be herbivorous as they were observed to feed on wheat kernels and blades of grass. Several specimens of this cricket were captured, however, far out in the dunes where no plant material exists. What they lived on in such a waste is hard to imagine. They were never encountered on the flats between the dunes.

Other species of insects were found on the dunes at night but were not active.

Arachnida

Araneae—One species of wolf-spider was discovered that dug tunnels down into the sand only in the flats between the dunes. The diameter of the tunnels was about that of a common lead pencil and were perhaps 8-10 inches in depth. The small spider was brown in basic color but its abdomen usually appeared as if covered with hoare-frost. This white color was easily rubbed off when individual specimens were handled. Individuals were observed coming to the surface at night to feed on small insects.

Solpugida (*Eremobates affinis* Krhla)*—This spider-like animal was observed on the sand one night and another one was captured under a tent floor. They were white in color and burrowed into the sand on the dunes during the day. One captive specimen kept in a battery jar with 3 to 4 inches of white sand in the bottom always spent the day in a tunnel in the sand or hid under some protective covering. The captive specimen fed on insects and displayed a most pugnacious attitude.

Scorpion (*Vejovis boreus* Gir.)*—A small light colored scorpion (about 30 mm. long) was found also under a bed roll one morning. In captivity he always burrowed into the sand during the day. Ewing (1928) states that this species is the most northern in its distribution of any American species. He gives as its natural distribution Arizona, Nebraska, Oregon, Idaho, Wyoming, Montana, South and North Dakota. Kurata (1930) reports this same species as well established in British Columbia. The specimen from the White Sands

†According to James A. G. Rehn of The Academy of Natural Sciences of Philadelphia, this is a new species of the genus *Daihiniodes*.

*Kindly identified by Nathan Banks, Museum of Comparative Zoology, Boston, Mass.

seems to be the first record of its occurrence from New Mexico.

A brown centipede was also dug up from a hole in a flat that resembled one of the spider burrows. The specimen was not captured so that it was not determined whether they dig in themselves or use the spider holes as a retreat.

The white mouse, lizard and several of the other mammal and reptile inhabitants have been recorded in the literature; but so far as I know practically none of the invertebrates have been reported. Some questions of interest that naturally arise from a study of these animals are the following: Is it temperature that governs the behavior of the day and night prowlers, or light, or both? What is the maximum temperature that various species can stand? Do all species react to a maximum temperature or is it different for different species? How have the light colored forms arisen and are they better fitted to survive than the dark colored forms? These and many others await solution and only intensive study of the area may answer them.

LITERATURE CITED

1. Benson, Seth B. 1933. Concealing coloration among some desert rodents of the southwestern United States. U. Calif. Pub. Zool., (40(1) :1-70.
2. Buxton, A. 1931. Animal life in deserts. London.
3. Chapman, R. N., C. E. Mickel, J. R. Parker and others. 1926. Studies in the ecology of sand dune insects Ecology, 7:416-426.
4. Chapman, R. N. 1931. Animal Ecology. McGraw-Hill Book Co., New York.
5. Dice, Lee R. 1930. Mammal distribution in the Alamogordo region, New Mexico., Occasional papers Mus. Zool., U. Michigan. No. 213:1-32.
6. Emerson, F. W. 1935. An ecological reconnaissance in the White Sands, New Mexico. Ecology, 16(2) :226-233.
7. Ewing, H. E. 1928. The scorpions of the western part of the United States, with notes on those occurring in northern Mexico. Proc. U. S. Nat. Mus. 73(9) :1-24.
8. Kurata, T. B. 1930. Notes on the northern scorpion *Vaejovis boreus* Giraud in British Columbia. Canad. Field Nat. 44(2) :28-30.
9. Ruthven, A. G. 1907. A collection of reptiles and amphibians from southern New Mexico and Arizona. Bull. Amer. Mus. Nat. Hist., 23:483-604.

*Kindly identified by Nathan Banks, Museum of Comparative Zoology, Boston, Mass.

Development and Reactions of Melanophores of Embryos and Larvae of Typhlogobius Californiensis Steindachner[1, 2]

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INTRODUCTION

Investigations concerned with the responses of the chromatophore system of the young of amphibians and fish have shown in most cases that this system passes through two physiological phases. The first response of the melanophores is to expand in light and to contract in darkness. This is believed to be a primitive reaction and the melanophores are assumed to be in the primary phase. Later in development and coincinding with the pigmentation of the eyes these melanophores show a reversal of their previous reaction, contracting in light and expanding in darkness, and are believed to be in the secondary phase in which the system remains throughout life. This reversal of the reaction to the primary phase response is believed to be due to the influence exerted indirectly by the eyes through the nervous system. This view was first emphasized by Babak (1910) and has since been confirmed by the experiments of Hooker (1914) on *Rana pipiens,* Laurens (1915, 1917) on *Amblystoma,* Fishel (1920) on amphibians, Duspiva (1931) on *Salmo salvelinus* and *Perca fluviatilis,* Tomita (1936) on *Macropodus opercularis,* Parker (1936) on *Mustelus canis,* and by Detwiler and Copenhaver (1940) on *Amblystoma.* It is to be noted that Parker records that the young of *Mustelus* omits the primary phase reaction to stimulation. According to a report of Coonfield (1940) the reactions of the melanophore system of the young of *Pomacentrus leucostictus* are at variance to those given in the reports previously cited. These young fish gave no consistant pigmentary reaction until a few hours before hatching. Beginning at this time and ending a few hours after hatching the melanophores of both the normal and the eyeless embryos and larvae contracted in response to a white background, expanded when over a black brackground, and contracted when in darkness. In view of these results and those of Parker previously cited, I decided to make further investigations of this problem of pigmentary responses of young fish. The young of *Typhlogobius* were selected because the eyes of this fish degenerate before they reach maturity, thus possibly giving some indication of the part taken by the eyes in the melanophore reaction.

EXPERIMENTS AND RESULTS

The visible body changes during the development of the embryos of *Typhlogobius* have been described by MacGinitie (1939). The eyes of these embryos appear to be perfectly normal just before they hatch and they remain in this condition until later in life. At this later period when these

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[2]Grateful acknowledgment is given to the Officers of California Institute of Technology for the use of the facilities at the Kerckhoff Marine Laboratory and to Professor G. E. MacGinitie, the director of this laboratory, for his valuable assistance and advice during this investigation.

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young take up their abode in the burrows of *Callianassa* the retina withdraws, becomes twisted out of shape, and these nonfunctional eyes are so covered with the skin that they are usually indiscernible, (Ritter, 1893). Even though the eyes are not functional this fish retains the ability to distinguish between strong light and darkness, though this reaction becomes less marked as the animal grows older and as its eyes are more deeply covered by the skin (MacGinitie, 1939). Since the structural changes of this fish have been described in the references cited, they will be mentioned only in this report in connection with the formation of and the reactions of its melanophores.

Fertilized eggs were secured very soon after the capsules were formed and they were separated from one another by breaking the fibrous mass which held them together. These embryos in groups of 50 and 75 were put into finger bowls; some were kept in a dark room while others were placed on a cement table in the laboratory. Those in the laboratory were separated and put into white bowls, black bowls, and clear bowls. All of these were illuminated approximately eight hours each day with a 50 watt lamp placed about one foot above the bowls. Frequent observations through a compound microscope made it possible to detect changes in the appearance and reactions of the pigmentary system as well as the development of these embryos.

During the first day of development there were very few visible changes (Fig. 1), but by the end of the second day the embryos had assumed an elongated shape (Fig. 2). On the third day the eyes were forming, the body length exceeded that of the yolk (Fig. 3), and a considerable amount of spasmodic muscular twitching was evident. At the end of the fourth day the bodies of the embryos were considerably elongated (Fig. 4) and, with the exception of the head region, very finely divided dermal pigment structures had appeared uniformly over the yolk and the embryo (Fig. 5). These structures formed the beginnings of the melanophores. The length of the body was on the fifth day almost equal to that of the capsule; pigment was forming in the eyes; and the previously finely divided pigment structures in the skin began to concentrate into larger bodies or melanophores. (Fig 6). Changes on the sixth day were less conspicuous, though there was a further increase in length of body and a definite increase in the retinal pigment (Fig. 7). The eyes were darker on the seventh day (Fig. 8) and many, small, yellowish splotches could be seen near the relatively large melanophores. A very slight response was exhibited by the melanophores to backgrounds on this day. The response was quite definite on the eighth day as evidenced by a contraction to a white background, expansion to a black background, and contraction to darkness (Figs. 9, 10). Although contraction and expansion were quite easily recognized on this day, more complete reactions of individual melanophores were evident in later development. The yellowish splotches which had appeared in the skin on the seventh day began on the eighth day to aggregate about the periphery of the melanophores which were increasing in size daily. During the ninth day of development the melanophores of the embryos which were kept in darkness became maximally contracted (Fig. 11) and it was observed that all melanophores had contracted. Though they showed greater contraction in response to darkness than to a white background, over which only a majority of them reacted, they showed quite definite contraction over the white background. (Fig. 12). The melanophores

EXPLANATION OF FIGURES IN PLATES I TO III INCLUSIVE

PLATE I

Fig.
1. Showing a developing embryo within a capsule, one day old. x app. 130.
2. A two day old embryo inside the capsule. x app. 130.
3. Three day old embryo, eyes forming but without pigment. x app. 130.
4. A four day old embryo, eyes without pigment but finely divided pigment has appeared in the skin. x app. 130.
5. Same specimen as in figure 4 showing the pigment in the skin. x app. 200.
6. Five day old embryo showing the skin pigment becoming concentrated into larger bodies. x app. 200.
7. Six day old embryo, the body having reached full length of the capsule, eyes still not fully pigmented. x app. 130.
8. Seven day old embryo with body longer than the capsule, eyes are pigmented. x app. 130.
9. Eight day old embryo subjected to a white background. x app. 200.
10. Eight day old embryo subjected to a black background, dorsal view. x app. 200.

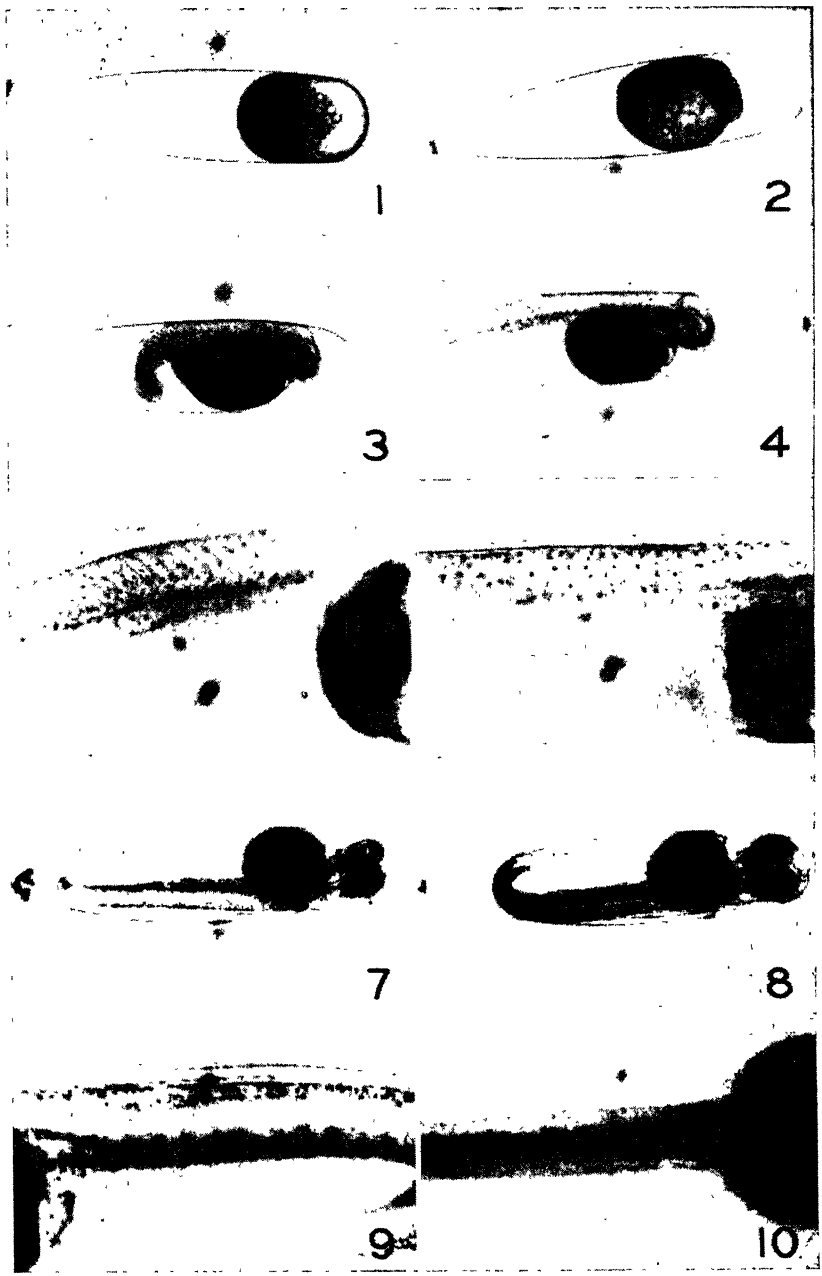
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PLATE II

11. Nine day old embryo kept in a dark room. x app. 200.
12. Nine day old embryo kept over a white background. x app. 200.
13. Nine day old embryo kept over a black background. x app. 200.
14. Ten day old embryos kept on a cement table. x app. 130.
15. Ten day old embryos kept in a dark room. x app. 130.
16. Ten day old embryo kept over a white background. x app. 200.
17. Ten day old embryo kept over a black background. x app. 200.
18. One day old larva kept over a white background. x app. 200.
19. One day old larva kept over a black background. x app. 200.

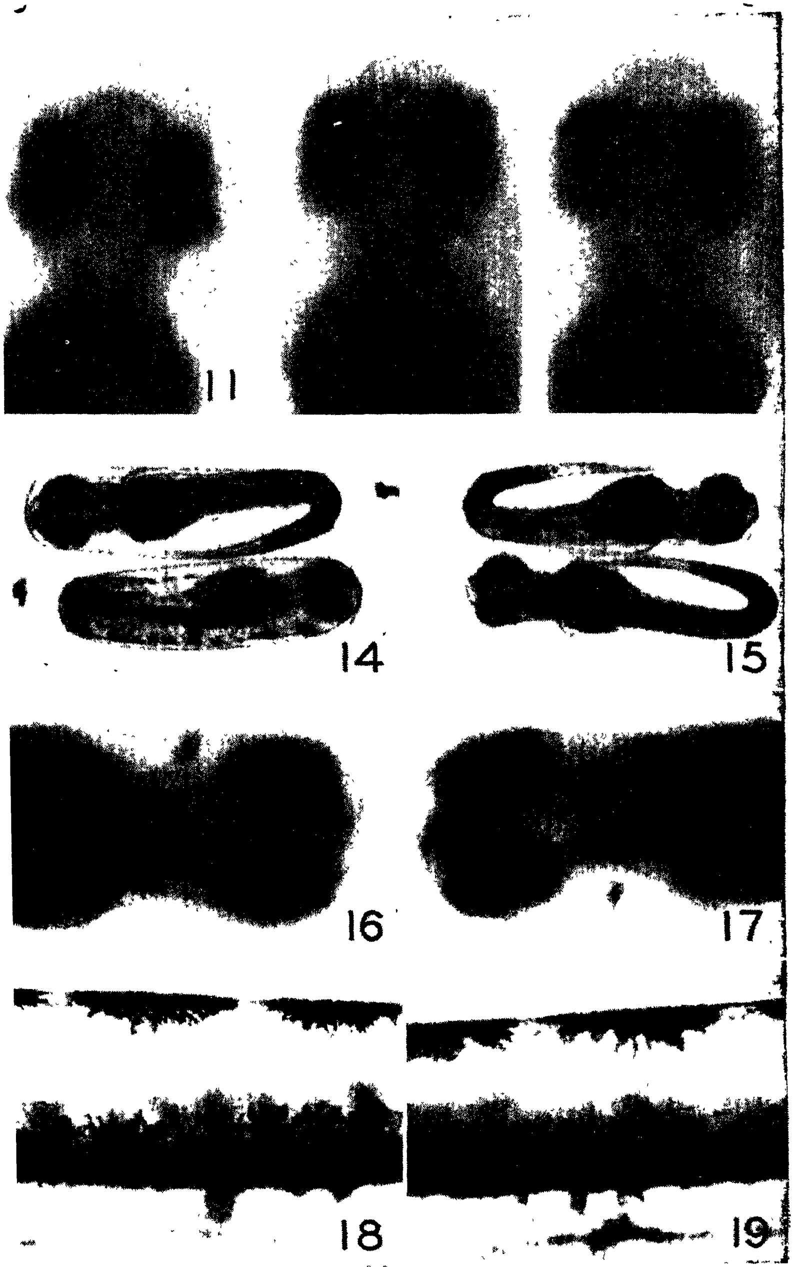
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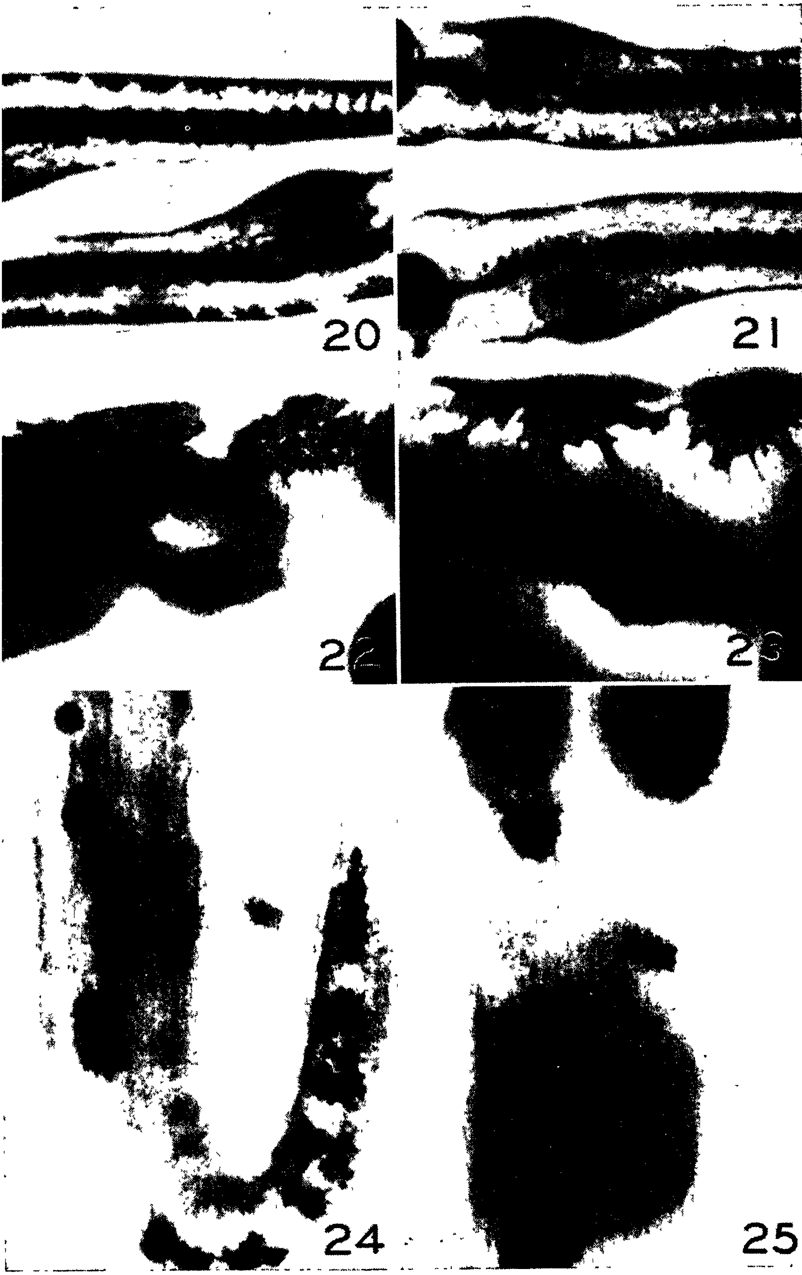
PLATE III

20. One day old larvae kept on a cement table. x app. 130.
21. One day old larvae kept over a white background. x app. 130.
22. One day old larvae kept over a black background. x app. 200.
23. Seven hour old larva kept over a black background. x app. 200.
24. One day old larva kept in a dark room, note that melanophores on tail region are not contracted. x app. 200.
25. Dorsal view of the same larvae seen in figure 24, head region. x app. 200.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expanded in response to a black background (Fig. 13). Most of the melanophores of the embryos which were kept in the clear bowls and under illumination on the cement table were expanded from the first day when any response could be seen and they continued in this state through the entire period of observation. On the tenth day of development the majority of embryos hatched, thus confirming the report of MacGinitie (1939). The young larvae gave the same melanophore response as in the embryonic stages, showing a contraction over a white background (Figs. 18, 21), an expansion over a black background (Fig 19), and an expansion over the dark, gray cement background (Fig. 20). Although these responses were easily recognized they were not as complete as they were before the embryos hatched (Figs. 14-17). This decrease in responsiveness was exhibited also by the older larvae (Figs. 22, 23) with the exception of those subjected to darkness. The older larvae in this situation continued to give full melanophore contraction throughout this observation which terminated ten days after the young hatched (Figs. 24, 25). At the end of ten days of larval growth it was very difficult to detect any reaction of the melanophores to backgrounds. My observations were discontinued at this time because the larvae had begun to die, probably because of the lack of suitable food.

DISCUSSION

Previous investigations have shown that the melanophores of young fish react to stimulation soon after these structures have been fully formed. Bancroft (1912), Spaeth (1913), and Gilson (1926) report a melanophore reaction in *Fundulus* embryos at the hatching stage. Becher (1929) who studied embryos of *Coregonus* and *Salmo,* Duspiva (1931) who observed embryos of *Salmo salvelinus* and *Perca fluviatilis,* Tomita (1936) who investigated the young of *Macropodus opercularis,* and Coonfield (1940) who reported the melanophore reactions of the young of *Pomacentrus leucostictus* have found a melanophore reaction in the embryos of these fish. My observations on the melanophore reactions of the young of *Typhlogobius* are in agreement with those of the last mentioned group of investigations. The melanophores of *Typhlogobius* embryos, which had appeared on the fourth day of development as finely divided bodies in the skin, responded to backgrounds on the seventh day of development, or three days before hatching. It is believed that these melanophores began reacting as soon as they were fully formed. Therefore it is well established that melanophores of certain fish embryos respond to stimulation before hatching.

Investigations have been made in an effort to determine what kind of stimuli are required to elicit a melanophore reaction in young fish. In this way it was presumed that some understanding of the reaction itself could be gained. Lowe (1917) experimenting with the larvae of *Salvelinus fontinalis* and Wyman (1924) studying the embryos of *Fundulus,* sought to explain this reaction on a chemical basis. Both of these investigators found no response by these embryo fish, but observed a reaction by the melanophores of these larvae. Wyman believed this reaction was due to a direct effect upon the melanophore protoplasm of the chemicals he used. Another view is shown by Coonfield (1940) who reports that the melanophores of *Pomacentrus* embryos reacted to a mechanical stimulus even before they responded to backgrounds or to darkness. In most investigations concerned with the prob-

lem of melanophore reaction in young fish and amphibians, light has been employed as the stimulating agent. These researches have shown in the majority of instances two types of reactions; a primary phase which is the first to appear and is usually transitory, and a secondary phase which comes later and is permanent when once it is established.

The responses of the melanophores of young fish and amphibians are quite characteristic and uniform during the primary phase. These color bodies will contract while the animal is in darkness and will expand while it is in light during the tenure of this phase. It is believed that this effect is produced by a direct action of the stimulating agent upon the melanophores. It is difficult to understand just how these melanophores could react without requiring some sort of a receptor system to receive the stimulus. Although this requirement appears to be necessary the facts brought out in certain investigations show that sense organs are not developed to any great extent in these animals at the time they exhibit this reaction. It is to a large degree this fact that has been the leading influence in believing that the melanophores respond directly to the stimulus.

How different are the organs of the larvae which exhibit the secondary phase to those of embryos which give the primary phase response? As far as the literature on the subject is concerned it is the full development of the eyes as receptor organs which marks the essential difference. While in the secondary phase reaction the melanophores expand while in darkness and they contract when in light. This contraction depends upon the amount of light perceived presumably by the eyes. It is noted that when the larvae which are in this stage of reaction revert to the primary phase reaction when they are blinded. This view that full development of the eyes brings about the change from the primary phase reaction to the secondary one would hold greater weight provided the larvae of all fish and amphibians followed this pattern. Data which showed a variation to this view were presented by Coonfield (1940) who reported that embryos of *Pomacentrus* exhibited a definite melanophore contraction over white background and an expansion over a black background before their eyes were fully formed. Furthermore the eyeless embryos and the larvae of this fish gave the same response to these backgrounds as did the normal embryos. Exactly the same sort of reaction was given by the embryos of *Typhlogobius* when they were subjected to these backgrounds as was reported for *Pomacentrus*.

Most researches dealing with melanophore reactions in the young of fish and amphibians have been concerned with an aim to find a melanophore coordinating system. When such a system is in evidence, a logical conclusion to be drawn thus far from the evidences gained is that this system is either nervous or glandular, or a combination of both The eyes then in this instance are believed to be the chief sensory organs functioning while these young are in the secondary phase reaction. Detwiler and Copenhaver (1940) made a convincing test of this view by grafting eyes to previously enucleated *Amblystoma* larvae in the regions where these grafts could establish connections to the blood stream without making the appropriate nerve contacts. These larvae according to them gave the same responses to light and to darkness as the enucleated ones without the grafts. In these instances the melanophores of both of these larvae contracted when in darkness while those of the

normal ones under a similar stimulation expanded. This reaction was due most likely they believed to the inhibitory influence of the eyes acting reflexly upon the pituitary. Laurens (1916) concluded the epiphysis of *Amblystoma* larvae has no influence on the reactions of their melanophores to light and to darkness. He reports further that the indirect stimulation of their melanophores through their eyes is not always opposite in effect to direct stimulation. According to the evidences obtained during the observations of the reactions of the melanophores of the embryos and larvae of *Typhlogobius* it is concluded that these responses are due to a direct stimulation. Though this conclusion is made, in all probability there are possibly light receptors in the skin of this animal at this stage of development. Should these receptors be present and functioning they would provide the receptors for the nervous system. It is quite likely that this is true since the adult of *Typhlogobius* has sensory structures in its skin.

SUMMARY AND CONCLUSIONS

1. Embryos of *Typhlogobius* possess very finely divided pigment bodies on the fourth day of development. These bodies begin to aggregate to form larger structures or melaophores on the fifth day.

2. The melanophores show their first slight response to stimulation on the seventh day of development and three days before hatching.

3. The pigment concentrated as large melanophores on the eighth day and at this time showed a very definite response by contracting when over a white background, contracting when in total darkness, and by expanding when over a black background.

4. The melanophores of larvae did not react as completely as those of embryos just before hatching. The melanophore response of young larvae was more vigorous than that of older larvae. The response of both of these larvae of different ages was the same as that of the embryos though not as complete.

5. The reactions of the melanophores of embryos and larvae of *Typhlogobius* are believed to be direct in response to the stimulations.

LITERATURE CITED

Babak, E. 1910. Zur chromatischen Hautfunkton der Amphibien. Arch. f. d. ges. Physiol., 131: 87-118.

Bancroft, F. W. 1912. Heredity of pigmentation in Fundulus hybrids. Jour. Exper. Zool., 12: 153-178.

Becher, H. 1929. Uber die Verwendung des Opak-Illuminators zu biologischen Untersuchungen nebst Beobachtungen an den lebenden Chromatophoren der Fischhaut im auffallenden Licht. Ztschr. f. wissensch. Mikrosc., 46: 89-124.

Coonfield, B. R. 1940. Chromatophore reactions of embryos and larvae of Pomacentrus leucostictus. Carnegie Inst. Washington, Pub. No. 517, 169-178.

Detwiler, S. R. and W M. Copenhaver. 1940. The growth and pigmentary responses of eyeless Amblystoma embryos reared in light and in darkness. Anat. Rec., 76: 241-257.

Duspiva, F. 1931. Beitrage zur Physiologie der melanophoren von Fischembryonen. Sitzungsber. Akad. d. Wissensch. Wein. Math. naturwiss., 140: 553-596.

Fischel, A. 1920. Beitrage zur Biologie der Pigmentzelle. Anat. Heft, Abt., 58: 1-

GILSON, A. S. 1926. Melanophores in developing and adult Fundulus. Jour. Exper. Zool., 45: 415-455.

HOOKER, D. 1914. Amoeboid movement in the corial melanophores of Rana. Amer. Jour. Anat., 16: 237-250.

LAURENS, H. 1915. The reactions of the melanophores of Amblystoma larvae. Jour. Exper. Zool., 18: 577-638.

LAURENS, H. 1916. The reactions of melanophores of Amblystoma larvae. The supposed influence of the pineal organ. Jour. Exper. Zool., 20: 237-261.

LAURENS, H. 1917. The reactions of the melanophores of Amblystoma tigrinum larvae to light and darkness. Jour. Exper. Zool., 23: 195-205.

LOWE, J. N. 1917. The action of various pharmacological and their chemical agents on the chromatophores of the brook trout, Salvelinus fontinalis Mitchill. Jour. Exper. Zool., 23: 147-193.

MACGINITIE, G. E. 1939. The natural history of the blind goby, Typhlogobius californiensis Steindachner. Amer. Mid. Nat., 21: 489-505.

PARKER, G. H. 1936 Integumentary color changes in the newly-born dogfish, Mustelus canis. Biol. Bull., 70: 1-7.

RITTER, W. E. 1893. On the eyes, the integumentary sense papillae, and the integument of the San Diego blind fish (Typhlogobious californiensis Steindachner). Bull. Harvard Mus. Comp. Zool., 24: 51-102.

SPAETH, R. A. 1913. The physiology of the chromatophores of fishes. Jour. Exper. Zool., 15: 527-585.

TOMITA, G. 1936 Melanophore reactions to light during the early stages of the paradise fish, Macropodus opercularis. Jour. Shanghai Sci. Inst., 2: 237-264.

WYMAN, L. C. 1924. The reactions of the melanophores of embryonic and larval Fundulus to certain chemical substances. Jour Experi. Zool., 40: 161-180.

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A Preliminary Survey of the Mollusca of Kingman County, Kansas

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The mollusks are a segment of the fauna of Kansas which has received little attention, although, the earliest studies began in the 80's of the last century. At that time Washburn College, Topeka, established a Biological Survey of Kansas and in 1885 published the first of a series of reports dealing with aquatic and terrestrial mollusks. This series of studies, which terminated after a few years, was directed by R. Ellsworth Call (1885). The collections of the Washburn survey included principally the forms of the eastern third of the state. Nothing approaching the Washburn studies has been done since the suspension of Call's work. Ferriss (1907) described a new sub-species of *Polygyra multilineata* from collections made by Chadwick along the Kaw River near Lawrence. Hanna (1909) published a list of the gastropods of Douglas County. A number of Hanna's species were taken from drift along the Kaw river, and may not be of local origin. Scammon (1906) studied the pelecypods of the state and published the only extensive account of these animals. Scammon's collections, like those of Hanna, are no longer available for study. Hanna and Johnson (1913) reported a list of 26 species of mollusks from Pleistocene deposits of Phillips County. Following Hanna's work in the state, the mollusks were completely neglected for nearly thirty years. Baker (1938) described two new species of gastropods from Upper Pliocene deposits of Meade County from collections made by Dr. Claude W. Hibbard, Curator of Paleontology, Dyche Museum of Natural History, The University of Kansas. Collections of mollusks made by Dr. Hibbard in Pleistocene deposits in Meade County were reported by Goodrich (1940), and referred to by Hibbard (1940) in a study of the vertebrate fossils of the region. Hibbard (1941) in a paper dealing with the vertebrate fossils of the Rexroad member, Ogallala formation, (Upper Pliocene) of Meade County, included a list of 24 species of mollusks collected from this formation in association with the vertebrate remains. Frye, Leonard, and Hibbard (1942) made a study of certain Pleistocene deposits along the Smoky Hill river in Russell County, and reported a list of 51 species of mollusks from this region.

Kingman County is a part of a nearly flat plain, and slopes towards the southeast. The altitude ranges from 1,340 ft. above sea level on the southeastern border to 1,840 ft. on the western border. The rise is gradual and constant.

The South Fork of the Ninnescah river drains the northern third of the county and the Chickaskia river drains the southern third. The crest known as the Cleveland Ridge forms the divide between these two plains. The soil along these two streams from places where most of the specimens were colleted is of the Arkansas loamy sand and Arkansas sandy loam types. This soil is found 3-6 feet above the normal water level of the streams. Many

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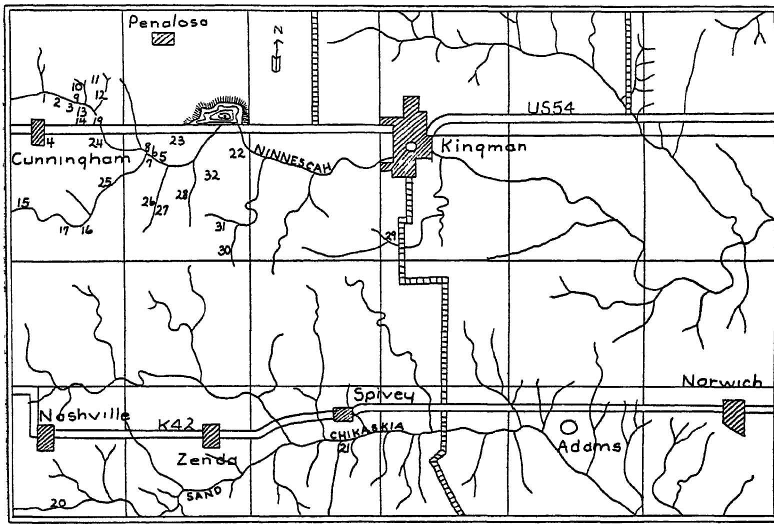
areas between the loam soil and the water levels are very sandy soils because of the rather frequent overflows in floods during the spring and the fall.

The mean annual rainfall of the county is 29.33 inches. About two-thirds



of the annual precipitation falls during the months from May to September, inclusive. The mean average for that period is 19.66 inches. The total amount for the driest year (1910) was 17.29 inches and for the wettest year (1915) 48.84 inches.

The mean average temperature for the year is 57.2° F. The average varies from 32.9° F. in January to 80.6° F. in July. During the winter the temperature usually drops far below zero for several days. During the summer and early fall hot, dry, southerly winds prevail.

The native trees are mainly willow, cottonwood, boxelder, elm, and ash. They are scattered chiefly along the drainageways and rivers. Catalpa groves which have been planted in a number of areas afford good habitats for mollusks. Many of these data were obtained from the report of Knobel, Lewis, Dornberger (1938).

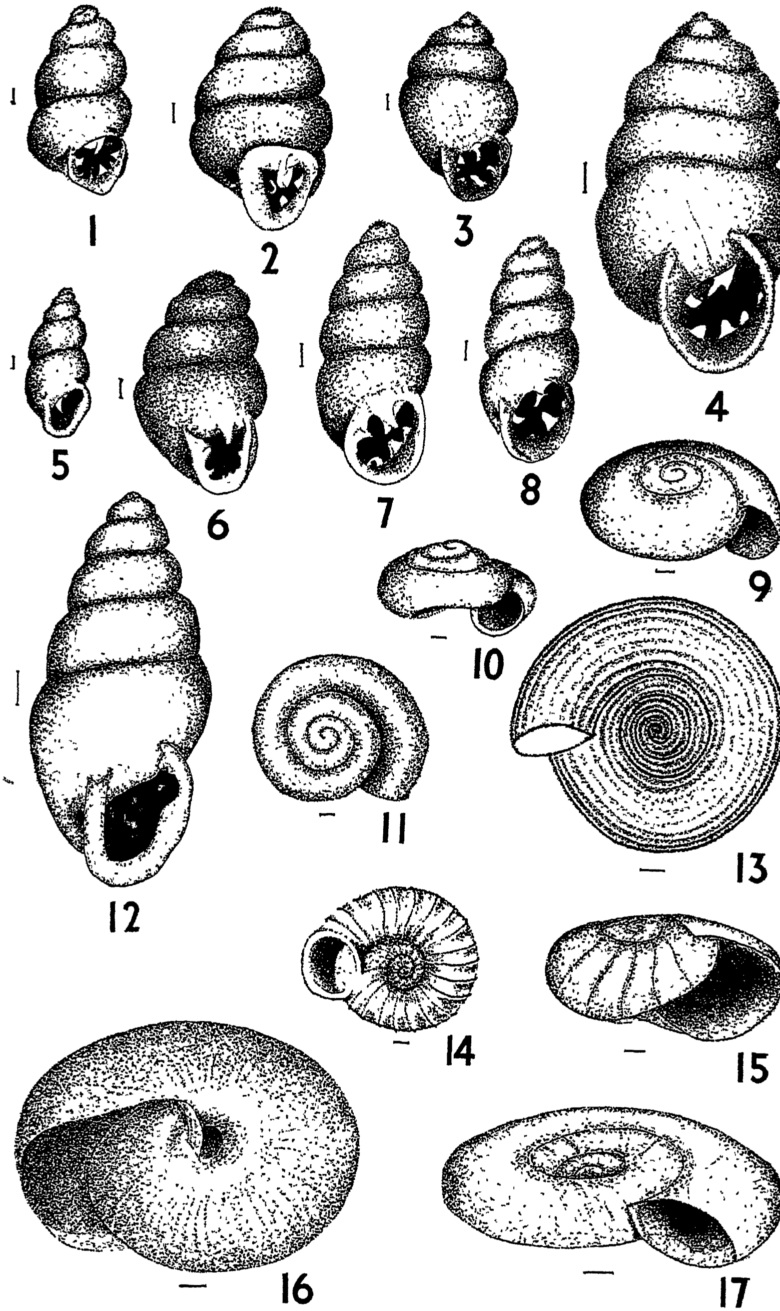
The territory included in this study may be divided into 4 general types of habitats: The first includes the northern drainage of the South Fork of the Ninnescah river. These streams are shallow with wide, sandy and sandy loam flood plains. The tree flora, which is comparatively sparse, consists mainly of cottonwood and willow. Although the ground becomes very dry during the prolonged drouths of the summer, it remains moist for some time after a period of heavy rains. The most favorable places are under logs, bark, and leaves on this moist ground near water and in drift at the edges of the streams.

The second habitat is along the streams of the southern drainage of this same river which are different from those of the northern drainage in that the timber growth is more dense and consequently the ground does not become as dry during the summertime. Here, too, the most favorable habitats are

PLATE I

Fig. 1—*Gastrocopta pentodon pentodon* (Say)
Fig. 2—*Gastrocopta contracta* (Say)
Fig. 3—*Vertigo ovata* Say
Fig. 4—*Gastrocopta armifera abbreviata* (Sterki)
Fig. 5—*Carychium exile* H. C. Lea
Fig. 6—*Gastrocopta tappaniana* (C. B. Adams)
Fig. 7—*Gastrocopta procera mcclungi* (Hanna and Johnson)
Fig. 8—*Gastrocopta procera duplicata* Sterki
Fig. 9—*Helicodiscus singleyanus inermis* H. B. Baker
Fig. 10—*Hawaiia minuscula* (Binney)
Fig. 11—*Hawaiia minuscula* (Binney)
Fig. 12—*Pupoides marginatus* (Say)
Fig. 13—*Helicodiscus parallelus* (Say)
Fig. 14—*Vallonia costata* (Müller)
Fig. 15—*Retinella indentata* (Say)
Fig. 16—*Zonitoides arboreus* (Say)
Fig. 17—*Gyralus parvus* (Say)

All figures 12x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those at the base of trees near the banks of the streams and in the moist drift at the very edge of the water.

A third habitat is that afforded by small catalpa groves. The trees are close and the ground is sufficiently shaded to remain moist to a certain degree even during the driest part of the summertime. Logs, bark, and leaves give an added shelter against the hot, dry, winds, and the summer's sun.

The fourth habitat consists of the wide, sandy, flood plains of the Sand Creek and the Chickaskia of the southwestern part of the county which are poorly shaded. Specimens are limited almost to drift near the water and at the base of a few large trees.

Few specimens were found except in association with the moist conditions obtaining in or near water or in shaded groves. When these places dry up, aquatic forms aestivate by burrowing down in the mud, while terrestrial species protect themselves against arid periods by secreting a membrane across the aperture. Both types of snails emerge and renew their activity upon the return of periods of rainfall.

Several methods of collecting were used. At times snails were found in the water, beneath bark of trees, or in soil, and were collected directly. Many specimens were obtained by collecting bark, organic debris and soil in large paper sacks. This material, after being properly marked with locality data, was sifted, or washed upon a fine screen. Specimens were sorted from this sifted or washed material, placed in separate containers, and finally identified. Careful attention was given to the matter of correct locality data, in order to obtain a picture of the distribution of the various species. All species reported have been catalogued in the collections of Dyche Museum of Natural History, the University of Kansas.

In all 26 species and subspecies of gastropods were collected from the western half of Kingman County. Terrestrial snails are represented by 7 families, 11 genera, and 18 species or subspecies. Aquatic forms include 3 families, 4 genera, and 8 species. Each of these species is listed below, together with reference to station numbers. Citations to literature refer to easily obtainable references.

FAMILY POLYGYRIDAE

Stenotrema fraterna (Say) Figure 18
Baker, 1939, p. 61
Stations: 2, 10, 14, 21, 32

FAMILY ZONITIDAE

Retinella identata (Say) Figure 15
Baker, 1939, p. 71
Station: 21

Hawaiia minuscula (Binney) Figures 10 and 11
Baker, 1939, p. 72
Stations: 1, 2, 3, 8, 10, 14, 15, 16, 17, 19, 20, 21, 23, 25, 28, 29, 30, 31, 32

Zonitoides arboreus (Say) Figure 16
Baker, 1939, p. 78
Station: 3

FAMILY ENDODONTIDAE

Helicodiscus parallelus (Say) Figure 13
Baker, 1939, pp. 88-89
Stations: 1, 2, 3, 5, 14, 16, 19, 21, 23, 25, 29, 32

Helicodiscus singleyanus inermis H. B. Baker Figure 9
Baker, 1939, p. 89
Stations: 14, 32

FAMILY PUPILLIDAE

Gastrocopta armifera abbreviata (Sterki) Figure 4
Baker, 1939, p. 97
Stations: 1, 3, 16, 17, 19, 20, 21, 23, 24, 25, 28, 32

Gastrocopta contracta (Say) Figure 2
Baker, 1939, p. 97
Station: 14

Gastrocopta pentodon pentodon (Say) Figure 1
Baker, 1939, p. 100
Stations: 1, 2, 3, 5, 10, 14, 16, 17, 19, 21, 23, 24, 25, 28, 31, 32

Gastrocopta tappaniana (C. B. Adams) Figure 6
Baker, 1939, p. 101
Station: 21

Gastrocopta procera mcclungi (Hanna and Johnson) Figure 7
Baker, 1939, p. 102
Stations: 1, 2, 3, 5, 8, 14, 15, 16, 17, 21, 23, 24, 25, 26, 27, 28, 29, 30, 32

Gastrocopta procera duplicata Sterki Figure 8
Stations: 1, 2, 3, 5, 8, 10, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 28, 30, 32

Vertigo ovata Say Figure 3
Baker, 1939, p. 105
Stations: 3, 5, 10, 14, 15, 16, 21, 23, 25, 26, 32

Pupoides marginatus (Say) Figure 12
Baker, 1939, p. 108
Stations: 1, 2, 3, 4, 5, 10, 14, 15, 16, 17, 19, 21, 23, 24, 25, 26, 28, 30, 32

FAMILY VALLONIIDAE

Vallonia costata (Müller) Figure 14
Baker, 1939, p. 119
Stations: 16, 17, 19, 21, 25

FAMILY SUCCINEIDAE

Succinea grosvenori Lea Figure 19
Baker, 1939, p. 121
Stations: 1, 3, 9, 10, 12, 13, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32

Succinea concordalis Gould Figure 20
Baker, 1939, p. 123
Stations: 2, 17

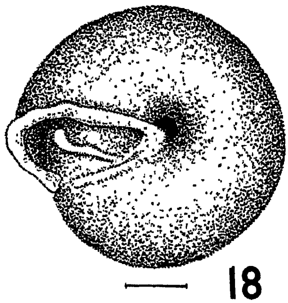
FAMILY ELLOBIIDAE

Carychium exile H. C. Lea Figure 5
Baker, 1939, p. 136
Stations: 2, 3, 8, 10, 14, 16, 17, 19, 21, 25, 32

PLATE II

Fig. 18—*Stenotrema fraterna* (Say)
Fig. 19—*Succinea grosvenori* Lea
Fig. 20—*Succinea concordalis* Gould
Fig. 21—*Physa anatina*
Fig. 22—*Lymnea humilis rustica*
Fig. 23—*Lymnea obrussa*
Fig. 24—*Lymnea palustris* (Müller)
Fig. 25—*Lymnea bulimoides techella*
Fig. 26—*Helisoma antrosa* (Conrad)
Fig. 27—*Helisoma trivolvis* (Say)

All figures 4x



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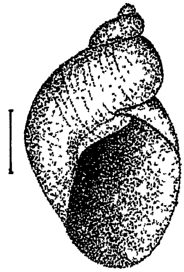

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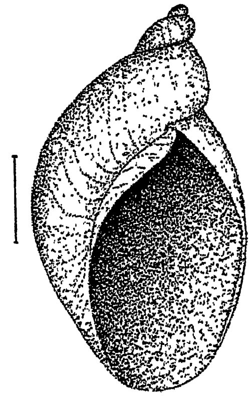

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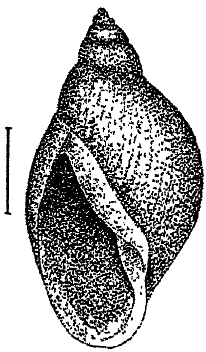

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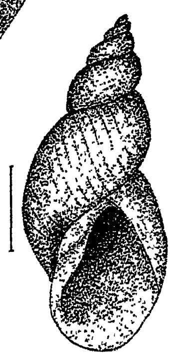

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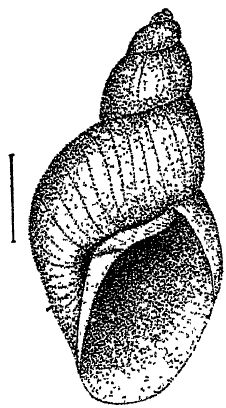

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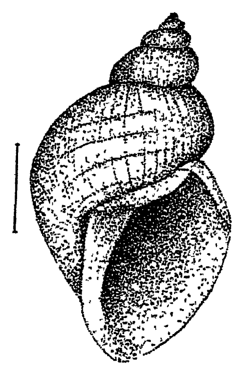

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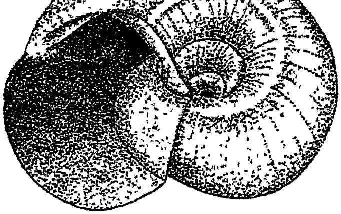

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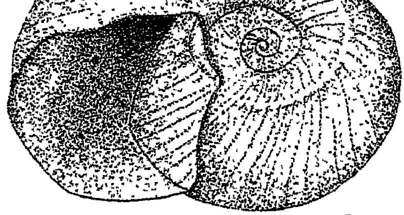

27

FAMILY LYMNAEIDAE

Lymnea bulimoides techella Pilsbry and Ferriss Figure 25
Baker, 1911, p. 214
Stations: 1, 3, 10, 17, 21, 23, 25, 28

Lymnea obrussa Say Figure 23
Baker, 1911, p. 270
Stations: 2, 3, 12, 14, 21, 28, 32

Lymnea palustris (Müller) Figure 24
Baker, 1911, p. 298
Stations: 2, 15, 20, 28

Lymnea humilis rustica (Lea) Figure 22
Baker, 1911, p. 268
Stations: 2, 14, 15, 17, 21

FAMILY PLANORBIDAE

Helisoma antrosa (Conrad) Figure 26
Baker, 1928, p. 317
Stations: 28, 32

Helisoma trivolvis (Say) Figure 27
Baker, 1928, p. 330
Stations: 28, 29, 32

Gyralus parvus (Say) Figure 17
Baker, 1928, p. 374
Stations: 3, 14, 15, 20, 21, 28, 32

FAMILY PHYSIDAE

Physa anatina Lea Figure 21
Stations: 1, 2, 3, 9, 10, 11, 14, 15, 17, 19, 20, 21, 23, 26, 28, 29, 32

Physa integra? Haldeman
Stations: 28, 29

The majority of the gastropods of western Kingman County are small terrestrial species that are capable of withstanding long periods of drouth. Among the aquatic forms, none are found that are dependent upon permanent water, and so far as known, all are able to bury themselves in moist earth during drouth periods, and thus remain alive until the return of favorable conditions. However, a tendency towards dwarfing was noted in many species, no doubt due to interruption of feeding by long, hot, dry, periods, and perhaps also to the lack of growth of fungus, upon which terrestrial snails are said to feed.

As might be expected, *Cochlicopa, Mesomphix, Polygyra, Anguispira, Strobilops,* and other forms rather common in eastern Kansas are not found in the area studied, although, *Cochlicopa* and *Strobilops* are common in Pleistocene deposits of western Kansas.

LITERATURE CITED

BAKER, FRANK COLLINS, 1911. The Lymnaeidae of North and Middle America Recent and Fossil. Chicago Acad. of Sci. Sp. Pub. No. 3.

———, 1928. The Fresh Water Mollusca of Wisconsin, Part I, Gastropoda. Wisconsin Acad. of Sci. Arts, and Letters.

———, 1938. New Land and Fresh Water Molluska From The Upper Pliocene of Kansas and a New Species of Gyraulus from Early Pleistocene Strata. Nautilus, Ap., 1938, Vol. 51, No. 4.: 126-131.

———, 1939. Fieldbook of Illinois Land Snails. Man. 2 Nat. Hist. Survey Div., State of Ill.

CALL, R. ELLSWORTH, 1885, 1886. Contributions to a Knowledge of the Mollusca of Kansas, Bull. Washburn College Lab. Nat. Hist. Vol. I, Jan. 1885, and ff.

FERRISS, J. H., 1907. A New Subspecies of Polygyra Multilineata. Nautilus XXI, No. 4; 37.

FRYE, JOHN C., LEONARD, A. BYRON, and HIBBARD, CLAUDE W., 1942. Westward Extension of the Kansas "Equus Beds" as Shown by Terraces, Abandoned Valley, and Associated Faunas. Jour. Geol. (in press)

GOODRICH, CALVIN, 1940. Mollusks of a Kansas Pleistocene deposit. The Nautilus, Vol. 53:77-79.

HANNA, G. DALLAS, 1909. Mollusca of Douglas County, Kansas. Nautilus, **23**: 81-82, 94-96.

HANNA, G. DALLAS and JOHNSON, EDWARD C., 1913. A Pleistocene Molluscan Fauna from Phillips County, Kansas. The Kans. Univ. Sci. Bull. Vol. VII, No. 3, Jan. 1913.

HIBBARD, CLAUDE W., 1940. A New Pleistocene Fauna from Meade County, Kansas. Trans. Kans. Acad. Sci. Vol. 43:417-425.

———, 1941. Mammals of the Rexroad Fauna from the Upper Pliocene of Southwestern Kansas. Trans. Kans. Acad. Sci. Vol. 44:265-313.

KNOBEL, E. W., LEWIS, R. O., and DORNBERGER, C. E., 1938. Soil Survey of Kingman County, Kansas. U. S. Dep't of Agri. Bureau of Chem. and Soils.

SCAMMON, R. E., 1906. The Unionidae of Kans. Kans. Univ. Sci. Bull. III No. 9:279-373.

The Influence of Certain Genetic Factors Upon Eye Color in the Guinea Pig[1]

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INTRODUCTION

The purpose of the work reported here was to determine the kind, amount, and distribution of pigment in the eyes of guinea pigs of known genetic constitution. The effects upon the eye of a few color-determining genetic factors have been studied, and an attempt has been made to integrate these observations with the results of earlier work on pigmentation of the skin and hair.

REVIEW OF LITERATURE

Knowledge of the genetic factors which influence eye color in guinea pigs has developed parallel to the study of the inheritance of coat color.

Castle and Allen (1903) showed that albinism in the guinea pig was due to a recessive factor c^a, which greatly reduced the pigment in the skin, hair, and eyes. The allelomorphic series C, c^k, c^d, c^r, and c^a, representing degrees of albinotic dilution, was described by Wright (1915, 1923). He showed that the factor c^r was responsible for the absence of red pigment in the coat, and for a certain translucence of the iris which gave the eye a reddish gleam in strong light. The factor C represented the highest degree of intense pigmentation in the hair and eye, while the factors c^k and c^d represented degrees of dilution intermediate between C and c^r.

Bogart and Ibsen (1937) recognized black and chocolate pigments as two different kinds of granules. They found both granular and diffuse pigments present in the hair, and they interpreted the actions of the "extension" factors in terms of relative amounts of diffuse and granular pigments in the hair. Following the work of Bogart and Ibsen (1937), Harman and Case (1941) studied the development and histology of the skin and hair in a number of genetic types of guinea pigs. They observed red granules in red hairs, and were able to explain the action of the extension factors in terms of the kind, rather than the amount of pigment granules in the hair.

Genetic factors which have been studied primarily with regard to their influence upon eye color include the recessive factor p (pink eye) described by Castle (1912), and the recessive factor sm (salmon eye) studied by Gregory and Ibsen (1926). The factor p has a marked diluting effect upon the black and chocolate pigments of the coat. Ibsen (unpublished) has since shown that the factor sm has a slight diluting effect upon these pigments, and that both factors dilute red pigment to some extent.

Sollas (1909) described the eyes of chocolate guinea pigs as "ruby" in color, indicating that they were more brownish than the eyes of black guinea

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[2]The authors wish to thank Dr. H. L. Ibsen, Kansas State College, for selecting from his colony the guinea pigs which were used, and for advice and criticism during the course of the work.

pigs, and in a favorable light reflected a dark reddish gleam.

Gregory (1929) examined histologically the eyes from guinea pigs of various genetic types. He showed that eyes of the genetic constitution c^a, p, or sm possessed very little pigment, while eyes from animals which carried the dominant allelomorphs of these genes, C, P, or Sm, had a large amount of pigment. The genes c^r and b caused a reduction of the melanin in the pigmented areas of the eye. He found that some pigment was always present, usually in the deeper retinal layer, even in the lightest eyes which he studied.

This work by Gregory (1929) together with earlier observations by Harman and Case (1941) formed the immediate basis for the present study of eye color in guinea pigs.

MATERIAL AND METHODS

Material: a synopsis of the factors studied:

- C: Red and dark (black or chocolate) pigments both present and intense. Dark eyes.
- c^r: Red pigment absent; dark pigment present and dilute. "Red" eyes.
- B: Black.
- b: Chocolate.
- E: Complete extension.
- e^p: Partial extension (one kind of spotting).
- e: Non-extension.

Animals representative of the following types were studied:[3]

- C B E: Self intense black; black eyes.
- C B e^p: Intense black-and-red; black eyes.
- C B e: Self intense red; black eyes.
- c^r B E: Self dilute black; "red" eyes.
- c^r B e^p: Dilute black-and-white; "red" eyes.
- c^r B e: Self white; "red" eyes.

A series of brown-eyed animals comparable to the above, in which b (chocolate) replaced B (black) was also studied. All of the animals used carried the factors P and Sm, hence none of them was pink-eyed or salmon-eyed. So far as could be determined, no other diluting factors were present in the stock. The C black, chocolate, and red animals were dark, glossy, show-types, and hence probably carried plus modifiers for intensity.

Most of the eyes which were studied in this problem were saved from guinea pigs of known genetic constitution, which had been carefully selected and bred for use in an earlier study of skin and hair pigmentation. This material was supplemented in a few instances by eyes from guinea pigs subsequently chosen for their eye and coat color.

Generally four to eight examples of each genotype were studied. Only two each of the C B e^p and c^r·b e types were available. However, the more numerous animals of other types studied were so consistent in appearance that we felt justified in assuming that the smaller groups were fairly representative of their particular genotypes.

[3]In referring to the genetic composition of the animals used in this problem, only the factor expressed in the zygote is mentioned. Most of the animals studied were homozygotes; but since dominance seemed to be complete, no distinction was made between the homozygous dominant and the heterozygote.

Methods:—The guinea pigs were killed with ether and both eyes were removed. A small opening was made in the eyeball so that the fixative might penetrate to all parts of the eye.

Bouin's fluid gave satisfactory fixation preceding sectioning and staining with hematoxylin and eosin. Since there was a possibility that the picric acid in Bouin's fluid might affect the appearance of the pigment, one eye of each animal was usually fixed in 8 percent neutral formalin or 95 percent alcohol, sectioned, and mounted unstained.

While the eyes were in 70 percent alcohol, a meridional segment including part of each region was carefully cut from the eyeball; the lens was removed through the opening thus made, and discarded. The segment cut from the eye was cleared and placed on a slide, unstained, as a whole mount. These slides were useful, not only for gross examination and estimation of the amount and quality of pigment in the different regions of each eye, but also for accurate examination of the shape, size, and number of pigment cells in the various layers.

The remainder of the eye was sectioned at 8-12^{u} and studied histologically. An excellent picture of the eye coloring was seen, and direct comparisons were facilitated, when the entire eyeballs were in the clearing fluid (tuluol). The descriptions which follow are based upon these as well as upon the sectioned material.

In each eye the following regions were observed and descriptions recorded:

COLOR AND QUALITY OF PIGMENT AND ITS GENERAL DISTRIBUTION

CHOROID:
- retinal epithelium
- lamina choriocapillaris
- lamina vasculosa
- lamina suprachorioidea

ORBICULUS CILIARIS:
- deeper retinal layer (continuation of retinal epithelium of choroid)
- vascular layer
- suprachorioidea

CORONA CILIARIS:
- deeper retinal layer (continuous with deeper retinal layer of orbiculus ciliaris)
- superficial retinal layer (continuation of the visual layer of the retina)
- stroma

IRIS:
- stroma
- anterior retinal layer (continuation of deeper retinal layer of corona ciliaris)
- posterior retinal layer (continuation of superficial retinal layer of corona ciliaris)
- pupillary margin

SCLERA

OBSERVATIONS

Granular pigment was the only type seen in the tissues of the eye. Various shades of black and chocolate were observed; no red granules were seen. For

each specimen, the quality of the pigment was the same in all regions where it occurred.

SELF INTENSE BLACK, BLACK EYES (C B E) (Fig. A, B, K, and L.)—The darkest eyes which were observed were from animals of the composition C B E. These are described first and used as a basis for comparison with the other types.

The pigment in the eyes of these black animals was in the form of very dark sepia granules, which appeared quite black where massed together. The eyeball, viewed as a whole, was black and opaque.

Choroid (Fig. B). The retinal epithelium appeared as a solidly pigmented stratum in which the outlines of the cells and nuclei were completely obscured by the pigment granules. The lamina vasculosa and lamina suprachorioidea contained abundant, densely pigmented branched chromatophores. The lamina choriocapillaris contained scattered chromatophores, and was also thickly pigmented.

Orbiculus ciliaris (Fig. L). The deeper retinal layer was about four times as thick as the retinal epithelium of the choroid, and its cells were densely and uniformly pigmented. The vascular layer and the suprachorioidea in this region both contained numerous chromatophores.

Corona ciliaris (Fig. K). The deeper retinal layer was thickly pigmented, especially on the crests of the ciliary processes. The superficial retinal layer was unpigmented, except on the anterior face of the ciliary processes next to the root of the iris, where in the space of a few cells it had as much pigment as the deeper layer. The stroma was well supplied with chromatophores except in a thin layer immediately under the deeper retinal layer. The fibers of the ciliary muscle were interspersed with densely pigmented cells.

Iris (Fig. A). The stroma contained a dense network of deeply pigmented chromatophores, which were slightly more abundant near the pupillary margin. Both the anterior and posterior retinal layers were thickly pigmented, especially at the margin of the iris. Outlines of the nuclei in the cells were not visible. The fibers of the sphincter and dilatator muscles of the pupil were interspersed with pigment granules, arranged in clumps and chains.

Sclera (Figs. B and L). Scattered clumps of densely pigmented cells were more abundant in the region of the ciliary body than elsewhere.

RED AND BLACK SPOTTED; BLACK EYES (C B e^p) (Figs. C and D)—Eyes from animals of the composition C B e^p were not as densely pigmented as the eyes from C B E animals. This dilution was particularly evident in the choroid, which as seen in the entire eye, was not opaque, but contained pigment cells arranged in branching stripes which followed the pattern of the blood vessels in the choroid. In C B E eyes the pigment in the choroid was so abundant as to obscure the blood vessels entirely.

Choroid (Fig. D). The retinal epithelium was densely pigmented, although the nuclei of some of the cells were distinguishable. The lamina choriocapillaris included only scattered pigment granules. The lamina vasculosa contained fairly abundant densely pigmented chromatophores which showed some tendency to cluster around blood vessels. This tendency was not noticeable in the eyes from E animals, since the pigment cells were so numerous as to occupy all of the space between the blood vessels of the choroid.

Orbiculus ciliaris; corona ciliaris. These two regions were pigmented to about the same extent in both E and e^p eyes.

Iris (Fig. C). The chromatophores in the stroma were somewhat scattered in the region just behind the pupillary margin, although they were densely packed with pigment granules. The posterior retinal layer was sparsely pigmented toward the root of the iris. The nuclei of its cells were not obscured by granules.

Sclera (Fig D). Pigmentation in the sclera was about the same as in the C B E eyes.

SELF DEEP CHERRY RED, BLACK EYES (C B e) (Figs. E and F)—In eyes from animals of this composition the iris was not opaque and the choroid, as seen in the entire eyeball, contained only a moderate amount of pigment in the spaces between the blood vessels.

Choroid. (Fig. F). The retinal epithelium appeared pigmented in the basal half of the cells. The lamina choriocapillaris was unpigmented. The chromatophores in the lamina vasculosa and lamina suprachoroidea, although densely pigmented, were scattered so that these layers appeared as an open network of pigment cells, rather than as dense strata.

Orbiculus ciliaris; corona ciliaris. Pigment in these areas was slightly less than in corresponding areas of E eyes, but the difference was no more than some of the variation which was seen among individual specimens.

Iris. (Fig. E). The stroma contained fewer chromatophores than present in e^p eyes. These were less abundant near the root of the iris, and they were not as densely pigmented as the cells of e^p eyes. The anterior and posterior retinal layers were both sparsely pigmented toward the basal half of the iris.

Sclera. (Fig. F). This layer included a very few chromatophores which were confined to the region near the ciliary body.

SELF INTENSE CHOCOLATE, BROWN EYES; (C b E) (Figs. G and H).—Pigment in the eyes of chocolate animals was in the form of yellowish brown granules.

In the entire eyeball the iris appeared as a dense but not opaque network of pigment cells. The choroid was moderately pigmented in the posterior third of the eye and more densely pigmented near the ciliary body. The latter was opaque.

Choroid (Fig. H). The retinal epithelium was sparsely pigmented in the posterior third of the choroid. The cells in the anterior part of the choroid contained more pigment, although the outlines of the nuclei were distinguishable. The lamina choriocapillaris was unpigmented. The lamina vasculosa and lamina suprachorioidea contained fairly abundant chromatophores.

Orbiculus ciliaris; corona ciliaris. The number and distribution of pigment cells in these regions were similar to that in the same regions of black eyes. However, the individual cells were only moderately supplied with pigment granules. This was true of the pigment cells from all parts of the eye.

Iris (Fig. G). Moderately pigmented chromatophores were abundant near the pupillary margin and scattered near the root of the iris. The cells of the anterior retinal layer were densely, and the cells of the posterior layer moderately pigmented, except near the root of the iris, where both layers were almost lacking in pigment.

Sclera. Scattered chromatophores were found near the ciliary body.

RED AND CHOCOLATE SPOTTED; BROWN EYES (C b e^p)—*Choroid.* The entire retinal epithelium was scantily pigmented. Chromatophores were somewhat fewer in the lamina vasculosa and lamina suprachorioidea than they were in the corresponding regions of E eyes.

Orbiculus ciliaris. The deeper retinal layer was densely pigmented, moderately pigmented cells were abundant in the vascular layer and in the suprachorioidea.

Corona ciliaris. The deeper retinal layer was densely pigmented in the crypts between the ciliary processes, and contained less pigment on the crests of the processes. Pigment was present in the superficial retinal layer only as scattered granules in those cells near the root of the iris. Moderately pigmented chromatophores were abundant in the stroma of the ciliary processes and among the fibers of the ciliary muscle.

Iris. The iris of the e^p chocolate eyes had somewhat fewer chromatophores than the iris of the E chocolate eyes. The distribution of chromatophores was similar in both types. In e^p eyes, both retinal layers were densely pigmented at the pupillary margin, and moderately to sparsely pigmented toward the root of the iris.

Sclera Scattered chromatophores were present near the ciliary body.

SELF DEEP CHERRY RED, BROWN EYES (C b e).—The eyeball as a whole appeared more translucent and lighter in color than the eyeballs of E and e^p animals of the composition C b.

Choroid The cells of the retinal epithelium were sparsely pigmented. There was an open network of pigment cells among the blood vessels of the lamina vasculosa; the lamina suprachorioidea contained abundant chromatophores, although it appeared as a comparatively thin layer of cells.

Orbiculus ciliaris. The deeper retinal layer was densely pigmented, chromatophores were scattered in the stroma and abundant in the suprachorioidea, although the latter was thin.

Corona ciliaris. The deeper retinal layer was densely pigmented posteriorly, with less pigment toward the front of the processes. In the superficial layer a few of the cells on the anterior face of the ciliary processes were sparsely pigmented. Scattered chromatophores were present in all parts of the stroma except the layer immediately under the retina.

Iris. The stroma contained an open network of branched pigment cells, which were more concentrated near the pupillary margin than elsewhere. Most of the pigment in the two retinal layers was concentrated in the cells at the pupillary margin.

Sclera. Moderately pigmented cells were scattered throughout the sclera, although most of them were near the ciliary body.

SELF DILUTE BLACK; "RED" EYES (c^r B E) (Figs. I, J, M. N).—When eyes of this type were compared with eyes from C B E animals, a marked difference was seen in the amount of pigment in the iris and choroid. These regions were opaque in the C eyes, but were thinly pigmented and translucent in the c^r eyes. The ciliary body, on the other hand, appeared as a conspicuous black ring in eyes of the of the latter type. The pigment granules in c^r E B eyes were dark brown.

In sectioned material it was seen that the reduced pigmentation in the c^r eyes consisted in (1) a reduction in the amount of pigment in the chromatophores, and (2) a decrease in the number of pigment cells. This was true of the orbiculus ciliaris and corona ciliaris, as well as of the iris and choroid, but due to the folding of the tissues in the ciliary body, that region did not appear translucent. There was no reduction in the number of pigment cells in the pigmented layers of the retina.

Choroid. (Fig. J). The retinal epithelium of the choroid was moderately to thinly pigmented, the lighter regions being near the posterior pole of the eyeball. The lamina vasculosa and lamina suprachorioidea were fairly well supplied with sparsely pigmented chromatophores.

Orbiculus ciliaris (Fig. N). The deeper retinal layer was very densely pigmented; moderately pigmented chromatophores were abundant in the vascular layer and in the suprachorioidea.

Corona ciliaris (Fig. M). The deeper retinal layer was densely pigmented except on the crests of the ciliary processes, where the outlines of the nuclei in the cells could be distinguished. In the superficial retinal layer there were a few thinly pigmented cells on the anterior face of the ciliary processes. Chromatophores were fairly abundant in the stroma, but they were thinly pigmented.

Iris (Fig. I). The pigment cells of the iris were numerous, but very meagerly pigmented, except in a small area at the root of the iris, where the pigmentation was thicker. The anterior retinal layer was moderately pigmented throughout; the posterior retinal layer was pigmented sparsely on the basal third of the iris and moderately on the distal two-thirds. The pupillary margin was darker than the rest of the iris chiefly because of the more abundant pigment granules in the cells there.

Sclera. A few pigment cells were seen near the ciliary body.

SPOTTED DILUTE BLACK AND WHITE; RED EYES (c^r B e^p).—The iris and choroid of these eyes contained less pigment than was present in the same regions of E eyes.

Choroid. The retinal epithelium contained very little pigment except toward the ora serrata, where it became moderately to densely pigmented. The same was true in general of the lamina vasculosa and lamina suprachorioidea. In the posterior part of the eye these layers contained scattered thinly pigmented cells; toward the ora serrata chromatophores were more abundant and were moderately pigmented.

Orbiculus ciliaris; corona ciliaris. Both of these regions were pigmented to about the same degree as they were in the eyes from c^r B E animals.

Iris. A few thinly pigmented chromatophores were present in the stroma. Both the retinal layers were thinly pigmented except at the pupillary margin, where there was enough pigment to cause this region to appear as a black ring in the entire eye.

Sclera. Occasional chromatophores were present near the ciliary body.

SELF B WHITE, RED EYES (c^r B e)

Choroid. The entire retinal epithelium was very thinly pigmented; there were only scattered granules present in the region near the optic nerve. The vasculosa and suprachorioidea contained a few sparsely pigmented chromatophores.

Orbiculus ciliaris; corona ciliaris. These regions were pigmented to about the same extent as they were in c^r E and c^r e^p eyes. Such differences as were seen were in some cases less than the individual differences within a genotype.

Iris. The stroma contained only a few thinly pigmented cells. Both retinal layers were sparsely pigmented except for the cells at the edge of the pupil, which were moderately pigmented.

Sclera. No pigment was seen in any part of the sclera.

SELF DILUTE CHOCOLATE; "RED" EYES (c^r b E). In the entire eyeball the iris and the choroid appeared very thinly pigmented; the ciliary body, while darker, was nowhere opaque, and there was a delicate rim of darker pigmentation around the pupil. Pigment granules in the eyes of these b animals were yellowish brown.

Choroid. The pigment granules in the retinal epithelium appeared as a delicate row of stippling. The lamina vasculosa contained only occasional pigment cells; the suprachorioidea included a few chromatophores; all were very sparsely pigmented.

Orbiculus ciliaris; corona ciliaris. Scattered lightly pigmented cells were present in the vascular layer of the orbiculus ciliaris and in the stroma of the corona ciliaris. The chief factor in the darker appearance of the ciliary body was the fairly heavy pigmentation in the cells of the deeper retinal layer.

Iris. The stroma contained a very few thinly pigmented chromatophores, except near the pupillary margin, where they were more abundant. Both retinal layers were moderately pigmented, with an increased amount of pigment near the pupil and a decreased amount near the root of the iris.

Sclera: The sclera was unpigmented.

SPOTTED DILUTE CHOCOLATE AND WHITE; "RED" EYES. (c^r b e^p).—Eyes of this composition differed from c^r b E eyes chiefly in having less pigment in the layers of the choroid and iris. The iris in particular contained a very delicate net of thinly pigmented cells, except near the root, where such cells were more abundant. Scattered chromatophores were seen in the sclera of one eye of this type.

SELF b WHITE, "RED" EYES (c^r b e). Only two animals of this type were available, and their eyes were not at all alike, although the animals were similar in appearance.

The eyes of one specimen were almost entirely lacking in pigment. Small numbers of lightly pigmented cells appeared in the choroid and ciliary body; a few were seen near the pupillary margin of the iris; and the cells of the deeper retinal layer of the ciliary body contained scattered granules. The latter region contained most of the pigment of the eye.

The eyes of the other animal were as densely pigmented as those from the c^r b E animals described on this page. The iris and choroid were translucent and lightly pigmented; the ciliary body was dark, although not opaque.

DISCUSSION

The phenotypes which were studied included all possible combinations of the factors C and c^r, B and b, E, e^p and e (considering each factor as paired either with itself or with a recessive allelomorph). Hence it was possible to analyze the influence upon eye color of each of these factors singly, and in combination. Since the eyes were from animals used in an earlier study of skin and hair pigmentation, it was thought that this material would permit

direct comparison of the influence of these factors upon both coat and eye color.

In describing the factors which influence eye color in guinea pigs, Gregory (1928) mentioned the possibility that the extension series E, e^p and e might have an effect upon the pigmentation of the eye. Our results indicate that this is true. In every combination observed, with the exception of one animal, individuals carrying the factor E had more deeply pigmented eyes than those carrying the factor e; and animals with the gene e^p (other factors being the same) had eyes in which the amount of pigment was intermediate between the other two. (Compare Figs. A to F, inclusive).

The reduction of pigment in the eyes of e^p and e animals consisted in the presence of a smaller number of chromatophores in the pigmented parts of the eye, especially the iris and the posterior half of the choroid, as compared with E eyes. The cells of the retinal epithelium were of course not reduced in number; but in the iris and choroid they were subject to some reduction in the amount of pigment granules which they contained.

The factors in the extension series appeared to have little or no effect upon the quality of pigment in the eye. In this, their influence upon the tissues of the eye is similar to that upon the pigments of the epidermis; but it is different from their effect upon hair color. Harman and Case (1941) found that the factors e^p and e produced absence of black or chocolate granules in part or all of the hairs of an animal. Instead of these dark pigment granules, red granules were found in C hairs while in c^r hairs, "pigment" granules were either colorless or absent. No red granules were present in any of the eyes observed in this study.

The density of pigment in the individual chromatophores of the eye apparently was not affected by the factors of the extension series.

One animal, of the composition c^r e b, constituted an exception to the above statements. Its eyes were as deeply pigmented as those of c^r E b animals, and were noticeably darker than the eyes from c^r e^p b animals. Other specimens, also of the composition c^r e b, had comparatively light colored eyes, as was true of other animals carrying the factor e. It is possible that the animal in question carried the factor B as an unrecognized mutation, or that modifying factors as yet unknown were present. It can be stated that at least some c^r e b animals showed reduction of pigmentation in the eye, as compared with E and e^p individuals.

Our observations agreed with the conclusions of Gregory (1929) that the factors B and b produced pigment granules of different hues. These factors had a comparable effect upon the pigment granules of the skin and the hair. The black pigment in black eyes was of the same color and appearance as the granular pigment in black hair. Chocolate granules also appeared the same in the eye as in the skin and hair.

Especially in c^r eyes, the black granules often were a medium brown shade, instead of the dark sepia seen in C black eyes. In each instance, however, the granules of black pigment were darker than the chocolate granules from eyes of the corresponding type. It is possible that the factor c^r dilutes the shade of both black and chocolate granules slightly and uniformly. Pigment in the skin and hair of c^r animals sometimes appears diluted in shade, as well as in the amount. Another possibility, equally applicable to the granules of the

skin and hair, is that both black and chocolate granules appear lighter where they are somewhat scattered, rather than massed together.

Gregory (1929) observed that the factor b reduced the number of chromatophores in most regions of the eye, and also decreased the amount of pigment which these cells contained. This was also true in the material studied in the present problem. (Compare Figs A and B with Figs. G and H).

Harman and Case (1941) observed that red diffuse pigment was present in the cortex of the fully formed hair, if there was any granular pigment present. It was especially abundant in red hairs. They considered this diffuse pigment as a product of the granular pigment in the cortex of the hair, rather than as one of the pigments primarily determined by the genetic composition of the animal.

No diffuse pigment was seen in any of the tissues of the eye. Upon the same basis, this may be explained as due to the fact that the eye does not contain the same type of cornified tissue as does the hair. This may also explain the absence of red granular pigment in the eye and skin, and its presence in the hair.

We can confirm the statement of Gregory (1929) that in most c^r eyes and in some C b eyes the pigment screen of the iris is incomplete, permitting light to filter through it to the retina and be reflected as a reddish "gleam". In the material which we observed, there was a marked reduction in the amount of pigment in the iris and choroid of c^r eyes. (See Figs. I and J, comparing them with Figs. A and B). It is suggested that the lightly pigmented choroid in these eyes might also absorb less light and reflect more than the heavily pigmented choroid of most C eyes.

The effect upon the eye of the factor c^r was a considerable reduction in the number of chromatophores and the amount of pigment in all parts of the eye. The reduction was best seen in the stroma of the iris and in the layers of the choroid. It was much more evident than the slight decrease in density of pigmentation which was associated with the presence of the factor b. The pigment in the skin and hair of c^r black and chocolate animals was correspondingly reduced.

Other factors which have parallel effects upon the color of the coat and of the eye in guinea pigs include the "salmon eye" gene (sm) which restricts the pigment as seen in the living eye to a ring of varying width around the margin of the pupil (Gregory and Ibsen, 1926; Gregory, 1929). Ibsen (unpublished) has observed that there is some dilution of the hair color in animals which carry this gene. The "pink eye" factor (p) was shown by Castle (1912) to dilute the black and chocolate pigments of the hair as well of the eye.

SUMMARY

1. A histological study was made of the eyes from guinea pigs of twelve different phenotypes, representing various combinations of the factors C and c^r, E, e^p, and e, B and b.

2. The factors E, e^p and e appeared to influence the amount, although not the kind of pigment in the eye. Where other factors were the same, E eyes were most heavily pigmented, e^p eyes showed a silght reduction in the pigment, and e eyes were pigmented to a still lesser degree.

3. Earlier observations that the iris of the eye in c^r animals was translucent, were confirmed. The reduction of pigment in the iris and choroid of c^r eyes, as compared with C eyes, consisted in (1) a smaller amount of pigment in the pigment cells, and (2) the presence of fewer chromatophores in most parts of the eye.

4. The factors B and b produced black and chocolate granules respectively in all pigmented parts of the eye. Also, the factor b effected a slight reduction in the number of pigment cells in the tissues of the eye. No red granules and no diffuse pigment were seen in any types of eyes observed.

5. In view of the fact that these and other factors have effects upon the color of the coat and eye which are comparable in many respects, it is suggested that the pigmentation of the animal as a whole should be studied as a genetic entity.

LITERATURE CITED

BOGART, RALPH, AND IBSEN, H. L., 1937. The relation of hair and skin pigmentation to colour inheritance in cattle, with some notes on guinea pig hair pigmentation. J. Genetics 35:31-59.

CASTLE, W. E., 1912. On the origin of a pink eyed guinea pig with colored coat. Science, n.s. 35:508-510.

CASTLE, W. E. AND ALLEN, G. M., 1903. The heredity of albinism. Proc. Am. Acad. Arts Sci. 21:603.

CASTLE, W. E. AND WRIGHT, SEWALL. 1916. Studies of the inheritance of guinea pigs and rats. Carnegie Inst. Wash. Publ. 241.

GREGORY, P. W., 1928. Some new genetic types of eyes in the guinea pig. J. Exp. Zool. 52:159-181.

GREGORY, P. W., 1929. A histological description of pigment distribution in the eyes of guinea pigs of various genetic types. Jour. Morph and Physiol. 47:227-259.

GREGORY, P. W., AND IBSEN, H. L., 1926. The inheritance of salmon-eye in guinea pigs. Amer. Nat. 60:165-171.

HARMAN, MARY T., AND CASE, ANNETTE A., 1941. Genetic aspects of pigment production in the guinea pig. Genetics 26:474-486.

SOLLAS, I. B. T., 1909. Inheritance of color and of supernumerary mammae in guinea pigs, with a note on the occurrence of a dwarf form. Reports to the Evol. Com. of the Roy. Soc. London, Report 5:51-79. (Original not seen).

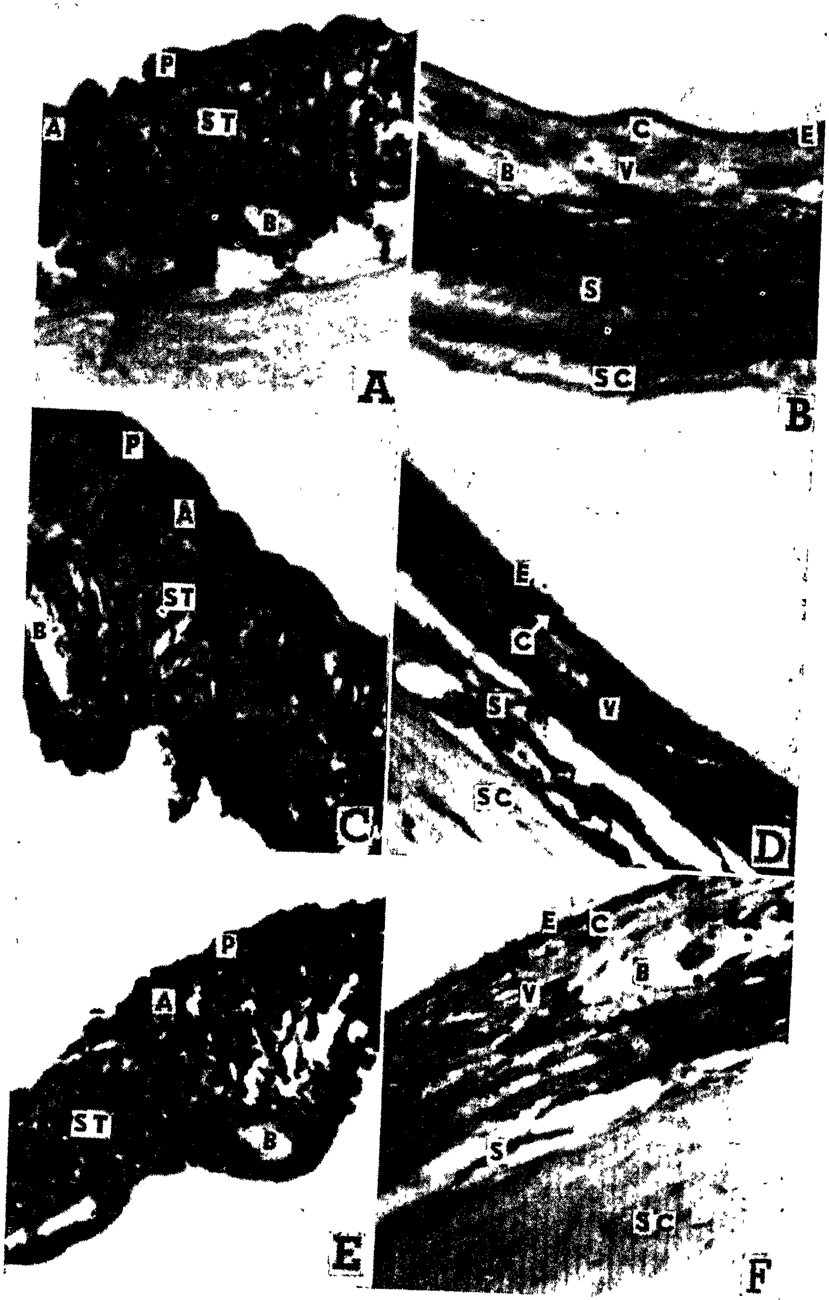
WRIGHT, SEWALL, 1915. The albino series of allelomorphs in guinea pigs. Amer. Nat. 49:140-148.

WRIGHT, SEWALL, 1923. Two new color factors in the guinea pig. Amer. Nat. 57:41-51.

EXPLANATION OF FIGURES

Figures are photographs of sections showing representative parts of the regions indicated. The tissues were stained very lightly with hematoxylin and eosin, to afford a contrast to the pigment, which appears black or dark gray in the figures. Photographs were taken under uniform exposure and lighting conditions. None were retouched.

Fig. A.—Iris from C B E eye
Fig. B.—Choroid from C B E eye
Fig. C.—Iris from C B e^p eye
Fig. D.—Choroid from C B e^p eye
Fig. E.—Iris from C B e eye
Fig. F.—Choroid from C B e eye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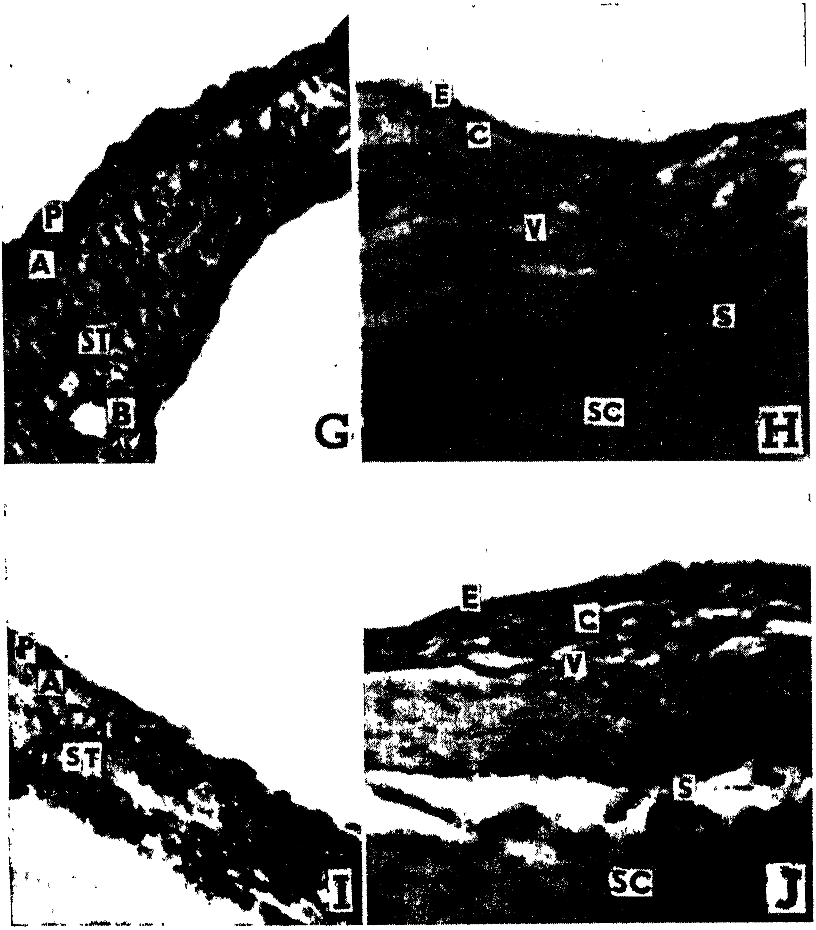

Fig. G.—Iris from C b E eye
Fig. H.—Choroid from C b E eye
Fig. I.—Iris from c^r B E eye
Fig. J.—Choroid from c^r B E eye

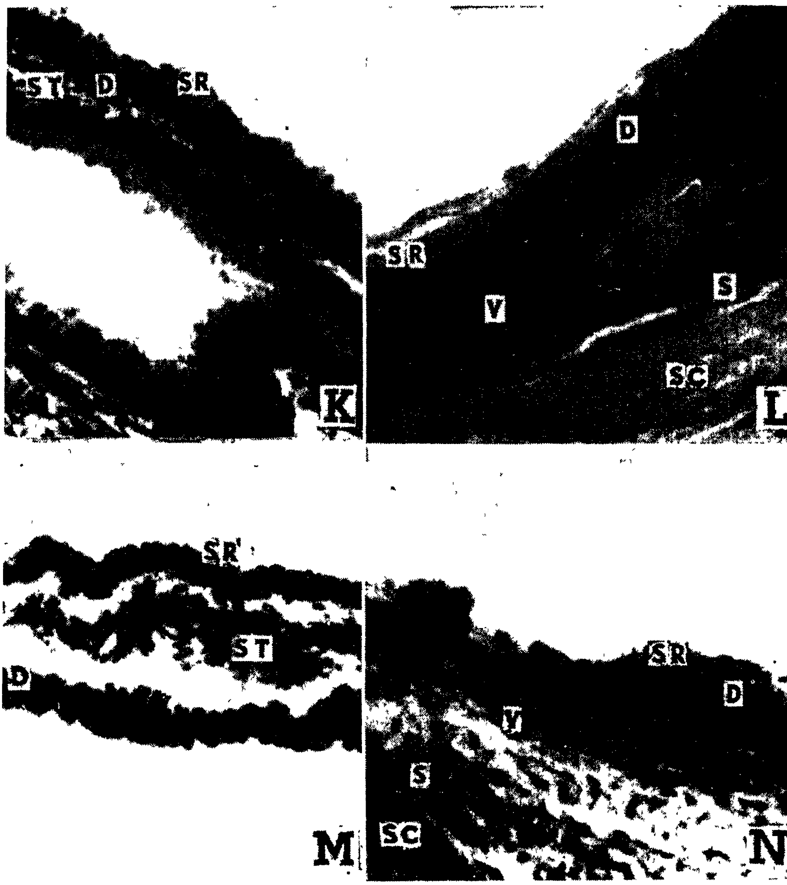

Fig. K.—Corona ciliaris from C B E eye
Fig. L.—Orbiculus ciliaris from C B E eye
Fig. M.—Corona ciliaris from c^r B E eye
Fig. N.—Orbiculus ciliaris from c^r B E eye

Key to Abbreviations

E, retinal epithelium of the choroid
C, lamina choriocapillaris
V, lamina vasculosa
B, blood vessel
S, lamina suprachorioidea
D, deeper retinal layer
SR, superficial retinal layer
ST, stroma
A, anterior retinal layer
P, posterior retinal layer
SC, sclera

Relationship of Barometric Pressures to Fishing Conditions*

ELMO W. HUFFMAN, Forestry, Fish and Game Commission, Pratt, Kansas

INTRODUCTION

In this era of mechanized living, the barometer has become an integral part of the modern fisherman's tackle. This study was made in an attempt to determine if his faith in this instrument is justified.

SOURCE AND NATURE OF DATA

On December 1, 1939, the Director of the Kansas Forestry, Fish and Game Commission instructed the State Park superintendents, whose parks contained lakes, to make daily reports on fishing conditions. These reports were to be shown as, "excellent", "good", "fair", "poor", or "none" and to be sent into the Pratt office on their Weekly Park Report forms.

It has been necessary for each superintendent to use his judgment in the interpretation of the meanings of the above enumerated fishing conditions. The superintendent of both the parks in Crawford county states that he calls a day in which the fishermen are catching a lot of fish, "good"; a day in which they are catching a few fish as, "fair"; and a day in which they tried but failed to catch any fish as "poor". He obtains his data from the fishermen as he checks their licenses. The Scott County State Park superintendent states that he calls a day in which 40 per cent of the fishermen are catching their limit as, "good"; one in which 15 per cent are catching their limit as, "fair"; and one in which only 5 per cent catch their limit as, "poor".

The Ottawa County State Park superintendent considers a good day one in which 50 per cent of the fishermen are catching fish; a fair day one in which 25 per cent of the fishermen catch fish; and a poor day one in which less than 10 per cent of the fishermen catch fish. He reports that one Salina fisherman uses the barometer as his guide and always has good "luck". The Leavenworth County State Park superintendent considers a good day one in which a majority of the fishermen catch fish enough to make their limits or near limits; a fair day one in which some fishermen make unusual catches but with the majority making no catches worthy of note; while a "poor" day is one in which no one seems to have any "luck". He also reports that many of his fishermen are using the barometer to guide their fishing efforts. For fear of incurring the wrath of the fishermen, who habitually complain of poor fishing, very few days are reported as, "excellent".

For two full years these reports have been sent into the Pratt office from the Scott, Ottawa, Butler, Leavenworth, Neosho, and Crawford No. 1 County State Parks. The reports from Crawford County State Park No. 2 started

*The author wishes to thank the Kansas Forestry, Fish and Game Commission for the use of its fishing condition records and the various State Park Superintendents for their interpretation of "good", "fair", and "poor" fishing days. He is especially indebted to Mr. S. D. Flora, federal meteorologist of the Topeka Weather Bureau Station, and to Mr. A. A. Justice, federal meteorologist of the Wichita Airport Weather Station, for their permission to copy the required barometric pressures after they were already reduced to sea level, for their advice on the stability of barometric pressure trends and for their careful review and constructive comments on the paper itself.

Transactions Kansas Academy of Science, Vol. 45, 1942.

on May 26, 1940 while Decatur County State Park No. 2 commenced reporting March 18, 1941. Woodson County State Park reported fishing conditions for the 1940 season only.

Because of the great number of days, previous to March 1st. and after November 30th, on which no fishing was reported, this study considers only the season between these dates. Only days on which definite reports were made are considered. Fishing conditions were recorded on a total of two thousand eight hundred ninety three days from the sixteen park seasons reporting.

Barometric pressure readings are not available from the parks, but records made at six hour intervals are available from nearby weather stations. Barometic pressures and trends are so persistent and uniform over large areas that reports from only four stations over Kansas were considered essential for this study. The station at Goodland was used for Decatur County State Park No. 2, while the Wichita airport weather station applied to Ottawa and Butler County State Parks. The Topeka station was used for the Leavenworth County State Park and the Chanute airport station was used for the Woodson, Neosho and both Crawford County State Parks. Records of barometric pressures, reduced to sea level in inches of mercury, for sake of uniformity, were copied as reported for 6:30 a.m. and 6:30 p.m. C.S.T. The 12:30 p.m. and 12:30 a.m. readings were noted and the trend in relation to the preceding reading designated.

PRESENTATION OF DATA

Table No. 1 is a tabulation of the recorded days and their percentages of occurrence for each type of fishing condition, arranged according to barometric pressure ranges in inches of mercury, reduced to sea level.

TABLE No. 1. A tabulation of fishing conditions on all the recorded days grouped according to barometric pressures reduced to sea level.

Barometer Range	Total Days	Total Per Cent	Good Days Days	Good Days Per Cent	Fair Days Days	Fair Days Per Cent	Poor Days Days	Poor Days Per Cent
29.50–29.70	157	5.4	17	3.8	59	5.4	81	6.0
29.70–29.90	820	28.4	160	35.8	297	27.1	363	26.9
29.90–30.10	1,335	46.1	190	42.5	514	46.9	631	46.7
30.10–30.30	484	16.7	70	15.7	198	18.1	216	16.0
30.30–30.50	97	3 4	10	2.2	27	2.5	60	4.4
Totals	2,893	100.0	447	100.0	1,095	100.0	1,351	100.0

The percentages for each type of fishing condition vary approximately as the percentages of the total days recorded in each range. A slight but persistent discrepancy occurs in the very high and very low ranges, indicating that these ranges are not conducive to good fishing. Almost nine per cent more of the good, than of the poor, fishing days occur in the range of 29.70 to 29.90.

Table No. 2 is a tabulation of the above data grouped according to barometric pressure trends.

Both good and poor days occur more frequently than the average, on days of falling barometer, but the days of poor fishing exceeds those of good fishing

on days of rising barometer. Steady barometer conditions appear to be more favorable to good and fair fishing.

TABLE No. 2. A tabulation of fishing conditions on all recorded days grouped according to barometric pressure trends.

Barometer Trend	Total Days	Total Per Cent	Good Days Days	Good Days Per Cent	Fair Days Days	Fair Days Per Cent	Poor Days Days	Poor Days Per Cent
R.sing	506	17.5	60	13.4	182	16 7	264	19.5
Steady	513	17.8	86	19.2	227	20.7	200	14.8
Falling	1,874	64 7	301	67.4	686	62.6	887	65.7
Totals	2,893	100.0	447	100 0	1,095	100.0	1,351	100.0

Of the total of sixteen park seasons tabulated, eleven indicated an excess of sixty per cent of some particular type of fishing condition. This persistency seemed to run in continuous periods and with little or no regard to barometric conditions. In an effort to make a better correlation of fishing conditions to barometric pressures the reports from the remaining five park seasons were tabulated for study.

Table No. 3 is a tabulation similar to that in Table No. 1, except for the selected five park seasons. It is seen that the chances for good fishing are quite small on days of very low and high barometer. The percentage of good days has a slight advantage over the percentage of poor days within the 29.70 to 29.90 and 30.10 to 30.30 ranges. In the middle range the percentages of good and poor days are about equal. In totalling the good and fair days it is seen that they exceed the poor days for the three central ranges but are less than the poor days on the two outer ranges.

TABLE No. 3. A tabulation of fishing conditions on selected parks for all recorded days grouped according to ranges of barometric pressures reduced to sea level.

Barometer Range	Total Days	Total Per Cent	Good Days Days	Good Days Per Cent	Fair Days Days	Fair Days Per Cent	Poor Days Days	Poor Days Per Cent
29.50 29.70	48	4.7	1	0.7	14	3.3	33	6.9
29.70 29.90	280	26.9	48	35.6	104	24.6	128	26.6
29.90 30.10	489	47.0	58	42.9	226	53.3	205	42.6
30.10 30.30	185	17.8	28	20.8	71	16.7	86	17.9
30.30 30.50	38	3.6	0	0.0	9	2.1	29	6.0
Totals	1,040	100.0	135	100.0	424	100.0	481	100.0

Table No. 4 is a tabulation similar to that in table No. 2, except for the selected park seasons. It is seen that the sum of the good and fair days are less than the poor days when the barometer is rising, but exceed the poor days at times of steady and falling barometer.

TABLE No. 4. A tabulation of fishing conditions on selected parks for all recorded days grouped according to barometric pressure trends.

Barometer Trend	Total Days	Total Per Cent	Good Days Days	Good Days Per Cent	Fair Days Days	Fair Days Per Cent	Poor Days Days	Poor Days Per Cent
Rising	177	17.0	13	9.6	69	16 3	95	19.8
Steady	199	19.2	26	19.3	94	22.2	79	16.4
Falling	664	63.8	96	71.1	261	61.5	307	63.8
Totals	1,040	100.0	135	100.0	424	100.0	481	100.0

Chart No. 1 is a presentation of the data given in tables No. 3 and No. 4. The results are a little difficult to analyze because of the great predominance

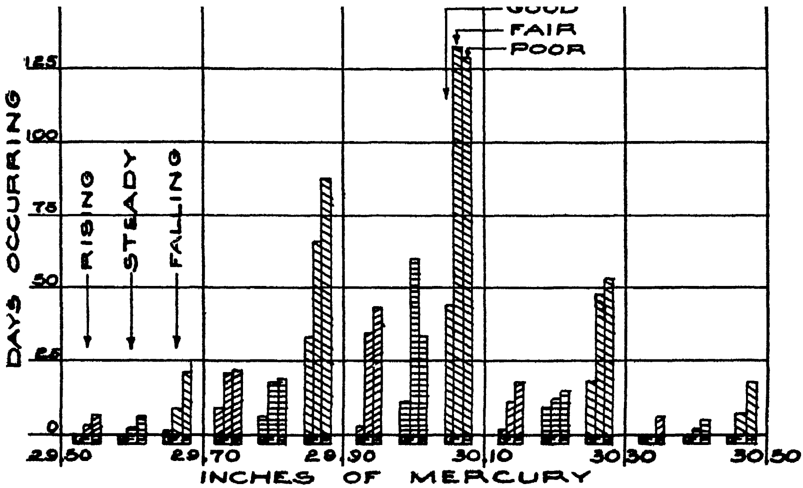

CHART No. 1

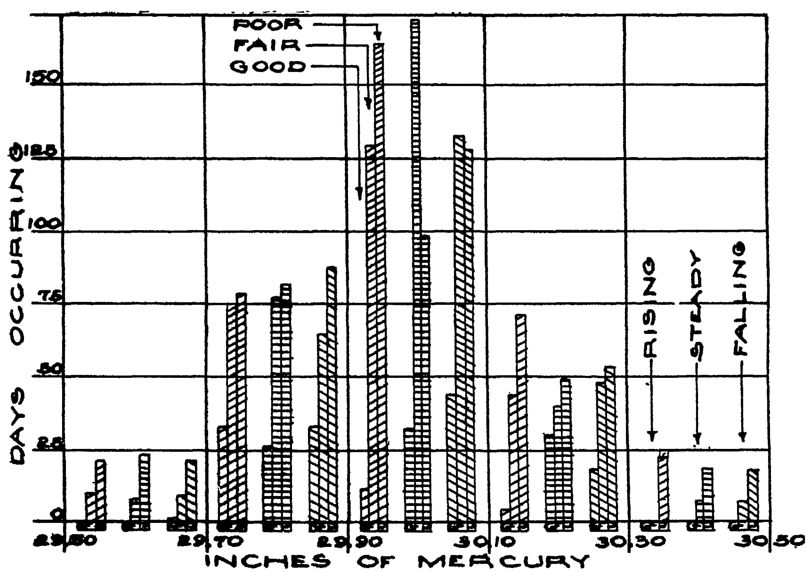

CHART No. 2

DESCRIPTION OF PLATE

Relationship of barometric pressures to fishing conditions

of falling days. In chart No. 2 the total of rising, steady, and falling days have been equalized within each barometric pressure range.

It is evident that the good days are practically absent from the very low and high ranges regardless of the trend. Within the 29.90 to 30.10 range, the number of good days increases steadily from rising thru steady and on to falling trends. The poor days follow almost the same pattern in the 29.70 to 29 90 range. Regardless of trend the sum of good and fair days exceed the poor days in the 29.70 to 29.90 range. For the ranges between 29.90 and 30.30 the total good plus fair days exceed the poor days on all but rising trends.

CONCLUSION

As a result of this study it would appear that fishing conditions are poor during periods of very low and very high barometric pressure, and that for the intermediate ranges, they are slightly poorer on days of rising barometric pressures. The fact, that good and fair fishing days were included in large numbers throughout the various trends, indicates that the majority of the environmental factors effecting fishing conditions are not directly connected with barometric pressures.

An accurate record of hourly fishing conditions, taken from various lakes over a long period of time, compared with the applying barometric pressures would form the basis of a most interesting study. In this paper the fishing conditions reported were based on the results of full days; likewise the barometric pressures and trends reported were average for full days. It is reasonable to believe that fluctuations of barometric conditions throughout a considerable number of days, covered by this paper, might have caused sufficient misinterpretation of the data to affect the results materially. Nevertheless, from a practical standpoint, the results available at present are considered of value because the average fisherman does not desire to change his fishing trip plans, hour by hour, even though barometric pressure readings are available.

Kansas Fish in the Kansas State College Museum at Manhattan[1]

DOLF JENNINGS, Kansas State College, Manhattan, Kansas

The collection of Kansas fish in the Zoology Museum of Kansas State College at Manhattan consists of 335 specimens representing 13 families, 41 genera, and 58 species or subspecies. Collections from any specific area are small with the exception of those from the Kansas River drainage in Riley County. This area is represented by fish of 11 families and 46 species. Other collections from the Kansas River and its tributaries duplicate the Riley County material in part and include some additional species. The Arkansas River is not represented in the collection except through the Neosho and the Verdigris River drainage. A few recent additions are from the Osage drainage in Osage County.

Early collections were made by I. D. Graham, then associated with the College, during the 1880's. All of his donations now in the museum, which have locality and time data, are for 1885 and 1886. He published one paper listing Kansas fishes in the museum which dealt with some earlier collections[2]. This earlier material was also listed in a report made in November, 1884, to the Kansas Academy of Science and published in 1885[3].

Specimens of 39 species mentioned in the early report are not in the museum now or if present they have been erroneously labeled as to locality or time of collection. Graham resigned from the College staff in 1898. In a recent letter to the author, he states that he found the fish collection greatly depleted when he visited the college at a later date. No records were found which explain these losses. The museum material was recatalogued in 1917 by Dr. Lee R. Dice, then Instructor in Zoology and Assistant Zoologist of the Agricultural Experiment Station, but the catalog apparently does not include specimens of these earlier collections.

A number of the larger specimens collected by Graham have locality labels for Fall River, Chase County. Fall River does not extend into Chase County and there have been no changes in county lines since the date of collection. Material so labeled is presumably from Greenwood County and has been so designated in the tabular summary.

The long period of time elapsing without a report on other specimens collected by Graham, and the present lack of knowledge in regard to all of his collections necessarily detracts from their value as records. However, they have been reported in the summary if locality data were available.

Other additions have been made to the museum from time to time by individuals associated with the College. Recent additions include material taken

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[1]Contribution No. 233 from the Department of Zoology, Kansas State College of Agriculture and Applied Science.

[2]Graham, J. D., Some Kansas Fishes in the College Museum. From a paper given before the Scientific Club. The Kansas Industrialist, Vol. X, No. 30, 1885.

[3]Graham, I. D., A Preliminary List of Kansas Fishes. Trans. Kans. Acad. of Sci., 9:69. 1885.

by M. J. Harbaugh, Assistant Professor of Zoology, and collections by the author and by students of the 1941 summer session field zoology class.

All Kansas material in the museum has been checked by the author and recatalogued. Identifications of material not before classified have been made and other identifications have been checked or corrected. Identifications were checked in part by comparison with specimens in the Kansas University collection. Doubtful identifications were referred to Dr. John Breukelman of Emporia State Teachers College. Identification of members of two species was made by Dr. Carl L. Hubbs of the Museum of Zoology the University of Michigan. The author is particularly indebted to Dr. Breukelman for aid in making identifications and for suggestions and information in regard to this work with Kansas fish.

The accompanying table shows the species, their number, county and stream from which collected, and date of collection.

TABLE 1.—Number, distribution by county and stream, and date of collection of Kansas fishes in the Kansas State College Museum.

Specimen	No.	County	Stream	Date
Family POLYODONTIDAE, Paddle-fishes				
Polydon spathula (Walbaum), Paddle-fish	1	Riley	Kansas R.	193..
Family ACIPENSERIDAE, Sturgeons				
Scaphirhynchus platorhynchus (Rafinesque) Shovel-nosed sturgeon	3	Riley	Blue R.	......*
	1	Riley	Kansas R.	1938
Family LEPISOSTEIDAE, Garpikes				
Lepisosteus platostomus Raf., Short-nosed gar	1	Riley	Blue R.	1928
	1	Riley	Kansas R. O.†	1942
Lepisosteus osseus oxyurus Raf., long-nosed gar	1	Lyon	Neosho R.	1938
	1	Riley	....	1916
	2	Riley	Blue R.	1941
Family HIODONTIDAE, Mooneyes				
Amphiodon alosoides Raf., Goldeye	2	....	Neosho R.	1885
	2	Riley	Wildcat Cr.	......*
Family CLUPEIDAE, Herrings				
Dorosoma cepedianum (LeSueur), Hickory shad	12	Riley	Kansas R. L.‡	1882
	10	Riley	Kansas R. L.	....
	4	Marshall	Blue R.	1885
Family CATOSTOMIDAE, Suckers				
Megastomatobus cyprinella (Valenciennes) Big-mouth buffalo	8	Riley	Kansas R. O.	1941
Ictiobus niger (Raf.), Black buffalo	1	Chase§	Neosho R.	1885
Ictiobus bubalus (Raf.), Small-mouth buffalo	1	Greenwood‖	Fall R.	......*
	2	Chase§	Neosho R.	1885
	2	Riley	Kansas R. O.	1941
Carpiodes carpio (Raf.), Cark sucker	1	Chase§	Neosho R.	1885
	3	Riley	Blue R.	......*
Carpiodes velifer (Raf.), blunt-nosed carp-sucker	3	Riley	McDowell Cr.	1940
Catostomus commersonnii (Lacepede), white sucker	2	Wallace	....	1885
	1	Riley	Kansas R. O.	1941
	1	Riley	Wildcat Cr.	1941
Minytrema melanops (Raf.), Spotted sucker	3	Chase	Rock Cr.	1885
Moxostoma erythrurum (Raf.), Common red-horse	1	Riley	....	......*
	2	Riley	Blue R.	1886
	1	....	Verdigris R.	......*
Moxostoma aureolum (Raf.), Northern red-horse	2	Greenwood	Fall R.	1885
	1	Riley	....	......*
	1	Shawnee	Wakarusa R.	......*
Family CYPRINIDAE, Minnows				
Cyprinus carpio Linnaeus, European carp	2	Riley	College Pond	......*
(Scale and mirror variety)	2	Riley	Kansas R. O.	1941
Carassius auratus Linn., Common goldfish	1	Riley	Kansas R. O.	1941
Semotilus atromaculatus atromaculatus (Mitchill), Northern creek chub	3	Trego	Saline R.	1885
	9	Pottawatomie	Blue Trib.	1941
	5	Riley	Kansas Trib.	1942

Specimen	No.	County	Stream	Date
Nocomis biguttatus (Kirtland), River chub	5	Chase	Rock Cr.	......*
	4	Osage	Dragoon Cr.	1941
Chrosomus erythrogaster (Raf.), Southern red-bellied dace	4	Pottawatomie	Blue Trib.	1941
	2	Riley	Deep Cr.	1942
Notemigonus crysoleucas auratus (Raf.), Golden shiner	4	Osage	Dragoon Cr.	1941
Notropis umbratilis umbratilis (Girard), Blackfin or redfin shiner	5	Riley	Wildcat Cr.	1941
Notropis atherinoides dilectus (Gir.), Shiner	14	Osage	Osage R.	1941
Notropis cornutus frontalis (Agassiz), Northern common shiner	1	....	Saline R.	1885
	6	Chase	Rock Cr.	1885
	....	Riley	Deep Cr.	1923
Notropis lutrensis lutrensis (Baird and Gir.) Redfin minnow	5	Osage	Dragoon Cr.	1941
	25	Riley	Deep Cr.	1942
Notropis topeka Gilbert, Topeka shiner	4	Osage	Dragoon Cr.	1941
	8	Riley	Wildcat Cr.	1941
Notropis deliciosus missuriensis (Cope), Straw-colored minnow	2	Pottawatomie	Blue Trib.	1941
	3	Riley	Deep Cr.	1942
Phenacobius mirabilis (Gir.), Sucker-mouth minnow	5	Osage	Dragoon Cr.	1941
	1	Riley	Wildcat Cr.	1941
Hybognathus nuchalis nuchalis Ag., Western silvery minnow	11	Riley	Kansas R.	1941
Hybognathus placitus placitus Gir., Plains silvery minnow				
Pimephales promelas: promelas x confertus, Fathead	5	Riley	Kansas R. O.	1941
	5	Riley	Kansas R. O.	1941
Hyborhynchus notatus (Raf.), Blunt-nosed minnow	1	Riley	Deep Cr.	1923
	3	Osage	Dragoon Cr.	1941
Campostoma anomalum pullum (Ag.), Central stoneroller	2	Chase	Rock Cr.	1886
Campostoma anomalum plumbeum (Gir.), Plains stoneroller	6	Riley	Wildcat Cr.	1941
Family AMEIURIDAE, Catfishes				
Ictalurus lacustris punctatus (Raf.), Southern channel cat	4	Chase	Rock Cr.	1885
	1	Riley	Wildcat Cr.	....
	1	Shawnee	Wakarusa R.	1885
Ameiurus melas melas (Raf.), Northern black bullhead	2	Riley	Kansas R. O.	1941
Ameiurus melas catulus (Gir.), Southern black bullhead	2	Osage	Dragoon Cr.	1941
Ameiurus natalis natalis (LeS.), Northern yellow bullhead	2	Riley	Kansas R. O.	1942
Pilodictis olivaris (Raf.), Mud-cat, Shovel head	2	....	Verdigris R.	1885
	1	Riley	Kansas R.	1941
Noturus flavus Raf., Stone cat	1	Riley	Blue R.	1941
Schilbeodes exilis (Nelson), Mad tom	1	Osage	Dragoon Cr	1941
Family ANGUILLIDAE, Eel				
Anguilla bostoniensis (LeS.), American eel	1	Riley	Blue R.	1885
Family CYPRINIDONTIDAE, Killifishes				
Plancterus kansae (Garman), Zebra minnow	12	Wallace	....	1885
	5	Pottawatomie	Kansas R. Tr.	1941
Family PERCIDAE, (Perch and Darters)				
Stizostedion canadense (Smith), Sauger, Sand pike	1	Chase	Rock Cr.	1885
Stizostedion vitreum (Mitchill), Wall-eye pike	2	....	Neosho R.	1885
	2	Riley	Kansas R. L.	......*
Hadropterus maculatus (Girard), Black-sided darter	1	Riley	Wildcat Cr.	1894
Hadropterus phoxocephalus (Nelson), Slenderhead darter	1	Osage	Dragoon Cr.	1941
Percina caprodes carbonaria B. & G., Log-perch	2	Riley	Wildcat Cr.	1888
	1	Riley	Wildcat Cr.	1889
	2	Riley	Wildcat Cr.	1894
Boleosoma nigrum nigrum (Raf.), Central Johnny darter	2	Pottawatomie	Blue Trib.	1941
	2	Riley	Deep Cr.	1942
Poecilichthys spectabilis pulchellus (Gir.), "Rainbow" darter	13	Pottawatomie	Blue Trib.	1941
	2	Riley	Deep Cr.	1942

Specimen	No.	County	Stream	Date
Family CENTRARCHIDAE, Sunfishes				
Micropterus punctulatus punctulatus (Raf.), Northern spotted bass	1	Chase	Rock Cr.	......*
Huro salmoides (Lac.), Large-mouth black bass	6	Chase and Greenwood	Fall R. and Rock Cr.	......*
	2	Riley	Kansas R. O.	1942
Lepomis cyanellus Raf., Green sunfish	3	Wallace	Eagle T. Cr.	1885
	5	Riley	Wildcat Cr.	1942
Lepomis humilis (Gir.), Orange-spotted sunfish	7	Riley	Kansas R. O.	1941
Lepomis macrochirus Raf., Bluegill	2	Leavenworth	Tonganoxie L.	1939
	1	Riley	Kansas R. O.	1941
Pomoxis annularis Raf., White crappie	2	Greenwood	Fall R.	......*
	3	Shawnee	Wakarusa R.	1885
	3	Riley	Kansas R. O.	1941
Pomoxis nigro-maculatus (LeS.), Black crappie	2	Riley	Kansas R. L.	1923
Family SCIAENIDAE. Sheepshead or Drum				
Aplodinotus grunniens Raf., Drum	1	Riley	....	......*

*Collection by I. D. Graham, presumably collected in 1886 or before, probably before 1885.

†O.—Abbreviation for overflow ponds left by floodwater.

‡L.—Abbreviation for lake or oxbow lake.

§The Neosho R. does not enter Chase Co.; probably an error in county rather than river.

‖All specimens designated Greenwood County were originally labeled Chase County.

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Notes on Mental and Physical Control Observed in Birds

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1

About 7 o'clock in the morning of Nov. 14, 1941, when it was barely clear daylight, three autos which were separated by distances of approximately 50 yards were traveling at the same speed and in the same direction along a concrete highway in Johnson County, Kansas. The writer was driving the last car. Suddenly a conspicuous member of the woodpecker family was observed to fly across the road well in advance of the first car. After alighting momentarily in a tree beside the road the bird suddenly flew almost directly toward the on-coming first car which was then only a short distance away. Yet, seeming to pay no attention to any possibility of disturbance, the bird lit not more than 4 feet from the edge of the concrete slab and began vigorously to peck at something on the ground. While both the first and the second cars were passing, the avid eater of a strange breakfast seemed to remain unconcerned, and even oblivious of our presence. This fact was particularly interesting because the second car was quite noisy. Even when the writer slowed down in passing, for purposes of closer observation and better identification, the large southern downy (A.O.U. No. 394) remained entirely unconcerned as to our close proximity. Because that breakfast seemed to be unusually important to the eater, there was no interruption. When the writer looked back from far down the road, the specimen was seen to fly back up into the trees. It is regretted that time did not then permit returning to the spot to learn the nature of the food. The identification later was confirmed by careful examination of the numerous skins and mounted specimens in Dyche museum at the University of Kansas.

2

For several seasons a large bird-house mounted on a pole in our farmyard, was used by purple martins (A.O.U. No. 611). During one season, numerous attempts to drive them away were made by a pair of loggerhead shrikes (A.O.U. No. 622), which nested in the orchard nearby. The shrikes seemed usually to be the aggressors; but the martins proved to be able fighters and unafraid. When attacked by the shrikes from the rear and above, the martins often were observed to turn over in flight back-downards and to use both claws and beak in fierce combat. Only for quite short distances, however, were they observed to fly in this way.

3

On another occasion this mode of warfare was observed in a fight between two hawks of different species.

While collecting botanical specimens on top of a Kansas hill, the writer's attention was attracted by the shrill screams of a bird fast approaching. On looking up, a marsh hawk (A.O.U. No. 331), was seen to fly past directly overhead at a height not to exceed 20 feet, carrying in its talons a burden

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which later proved to be a half-grown quail that was still alive. Close behind and gaining fast, came a fine specimen of red tail (A.O.U. No. 337) which seemed determined to rob the smaller bird of its prey. On catching up, the aggressor struck so fiercely that the marsh hawk, screaming angrily, instantly dropped the quail, turned over on its back and returned the battle with both talons and beak, costing one or both birds some feathers. At the same time the marsh hawk continued its flight in this manner in almost a straight line for a distance of nearly two hundred yards.* On reaching the edge of the hill, the pursued dropped instantly into some trees at the foot of the steep hillside; with shrill cries of disappointment, the pursuer swept on over the grove and soon was lost to view.

The quail, when released, caught up its flight before hitting the ground and, with rapidly beating wings, skittered off to one side where it dropped into hiding in some high grass.

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*The following comment on the above incident has been received from Dr. Alexander Wetmore of the U.S. National Museum:

"It is not unusual for hawks when fighting or playing in the air to turn back downward for a limited space to allow use of the feet in protection against some attacker swooping from above. The raven in soaring and gliding sometimes turns back down to coast along for a number of feet. I have observed this on several occasions."

Some Observations of the Food Coactions of Rabbits in Western Kansas During Periods of Stress

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INTRODUCTION

Rabbits are common residents of the Great Plains grasslands and cultivated areas and are the most plentiful wild game animals of the region. Until recent years, they were considered of little economic importance and were hunted for pure sport, or poisoned and killed off as nuisances to crops and trees. Today in Kansas alone, jackrabbits, in particular, are furnishing the raw material for a two million dollar industry (1).

These rabbits depend, for the most part, upon native vegetation for their food and cover. This is particularly true on range land. The following observations were made and data obtained on pastures and their adjacent areas in western Kansas during the fall drought of 1939 and the winter snows of 1940, 1941 and 1942. These studies were made to determine the native vegetation which was being eaten by rabbits during periods when the normal plant cover was unavailable to them.

RELATED STUDIES

Palmer, (3) reported that on the Plains the rabbits ate buffalo and grama grass and such herbs as could be found, supplemented by willow bark in winter. In deserts they were fond of annual species of greasewood (Atriplex) and several species of cactus.

In his study of cottontails in relation to farm crops, Lantz (2) states that rabbits (both jack and cottontail) feed exclusively on vegetation of all kinds and are at times harmful to crops.

Vorhies and Taylor, (6) in their extensive studies of jackrabbits in Arizona found that the blacktailed jackrabbit consumed 56 per cent mesquite and 24 per cent grass. Rabbits showed a fondness for grass, but during drought periods ate considerable cactus.

FOOD COACTIONS

The blacktailed jackrabbit (Lepus californicus melanotis) is a true herbivore, rarely eating animal material and then possibly by accident. The chitinous coverings of insects have been observed in a very few fecal pellets of this lagamorph, but they are not a part of the rabbit's regular diet. The jackrabbit seems to prefer succulent plant food when it is obtainable, but when adverse conditions arise, the blacktailed jackrabbit readily adapts itself to eating other possibly less palatable vegetation.

In western Kansas observations of plants gnawed by these rabbits and the finding of seeds and plant remnants in their fecal pellets indicated that certain plants were favored for their food in both normal and adverse times. The more popular ones were: prickly pear cactus (*Opuntia sp.*), broom weed (*Gutierrezia sarothrae*), pig weed (*Amaranthus sp.*), and sand dropseed

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(*Sporobolus cryptandrus*). These plants are eaten particularly during the fall and winter months.

Both the fruits and the flat succulent stems of the prickly pear are eaten with apparent relish by jackrabbits. A resulting coaction of the eating of the cactus fruits by the rabbits is the spreading of cactus seed in their fecal pellets (4).

The broom weed is a perennial composite appearing on the thin soil of rocky outcrops. It is eaten by the jackrabbits during the fall and winter months. The broom weed stem, below the much-branched broom or flower-bearing top, bears small, green rosettes of leaves from the lateral buds during the winter dormant period. The rabbit cuts the stem off near the base of the plant and consumes a portion of the lower end of the rosette-covered stem. (Fig. 1).

The pigweed is eaten while green or in a dried state and occasional seeds of the plant are found in pellets in late summer and during the winter.

The seed of sand dropseed grass is found in jackrabbit pellets from the time the grass matures seed in late summer until growth has been resumed the following spring. It appears to be a staple food of rabbits wherever it is found in western Kansas.

Plants Used for Food During the Drought

Drought, with its ensuing reduction of green plant life, apparently presents a moisture problem to jackrabbits. During the severe drought of the fall of 1939 observations at several places in western Kansas indicated that rabbits were attacking the crowns and succulent roots of the blazing star (Fig. 2) and purple cone flower digging away the soil and gnawing off the roots of the plants as much as two inches below the surface of the ground. Prickly pear fruit and pads were consumed in great quantities. Other plants observed to be used by rabbits for food during drought periods have been listed in Table 1.

Plants Used for Food After Heavy Falls of Snow

During the past three winters studies were conducted after heavy snows had fallen on pasture land near Hays, Kansas, to determine what plants rabbits were eating when normal vegetation was buried beneath the snow.

Some of the snows were five inches to seven inches deep on the level (Fig. 3) and the intense cold which usually accompanied them made it necessary for the rabbits to obtain considerable amounts of food to prevent their freezing.

One of the most commonly eaten plants under these conditions was the dry Russian thistle. Portions of the dead stems, still retaining their spiney leaves were eaten where they projected above the snow in the fields. Where the thistles had collected in ravines and along fences large numbers of pellets and stubs of the thistle stems showed the plant remnants had furnished food and shelter for the rabbits. In some instances the rabbits had even dug into the snow to reach the thistles. (Fig. 4). Remnants of several plants were noted to have been bitten off above the snow and eaten while prickly pear and short grass had been obtained by digging away the snow.

The leaves of the soap weeds, (*Yucca glauca*) on the sides of the plants away from the wind, were observed to have been bitten off, giving the plants a lopsided appearance. Many of the seed stalks and stems of sand dropseed

were eaten as they projected above the snow and pellets collected in the vicinity of the sand dropseed contained many of the tiny seeds of the grass.

Shrub plants of the pasture land were severely pruned and girdled where they projected above the snow. Western sand cherry (*Prunus besseyi*) and ill-scented sumac (*Rhus trilobata*) were attacked vigorously. A clump of ill-scented sumac, nearly covered by a snow drift, was observed to have had nearly all the upper branches bitten off, removing at least five inches of terminal growth. A small tree nursery near an alfalfa field was severely damaged. The rabbits had climbed on the drifted snow and girdled hundreds of honey locust trees 18 inches to 24 inches above the ground.

Rabbits appear to suffer little from the eating of spiny plants. In addition to prickly pear and Russian thistle, the buffalo bur (*Solanum rostratum*) was noted to have been eaten in weedy areas covered with snow. The dry, nettle covered hulls of the berries appeared to be the preferred part of the plants. That rabbits swallow some of the sharp pointed appendages of these plants is evidenced by the presence of the spines of both the prickly pear and buffalo bur in the fecal pellets. Some of the spines were in excess of ¼-inch in length and in an excellent state of preservation, neatly embedded in the vegetative material of the pellets.

Some other plants eaten during snowy weather are listed in Table 1.

COTTONTAIL (SYLVAGUS SP.)

Food Coactions During Drought

The food coactions of the cottontail during drought closely follow those of the jackrabbit. Fecal pellets gathered near cactus plants in 1939-40 indicate that it feeds on cactus fruits and to some extent on the succulent pads. Their pellets have been found where roots of prairie cone flower and blazing star were dug out and eaten. The rosettes of wild lettuce (*Lactuca ludoviciana*) were found to be taken for food by cottontails near the college campus. The use of broom weed, pigweed, sand dropseed and cactus for food during periods of plenty as well as during periods of stress, appeared to be a common practice of the cottontail, particularly when these foods were available close to cover used by these animals.

Food Coactions During Snow

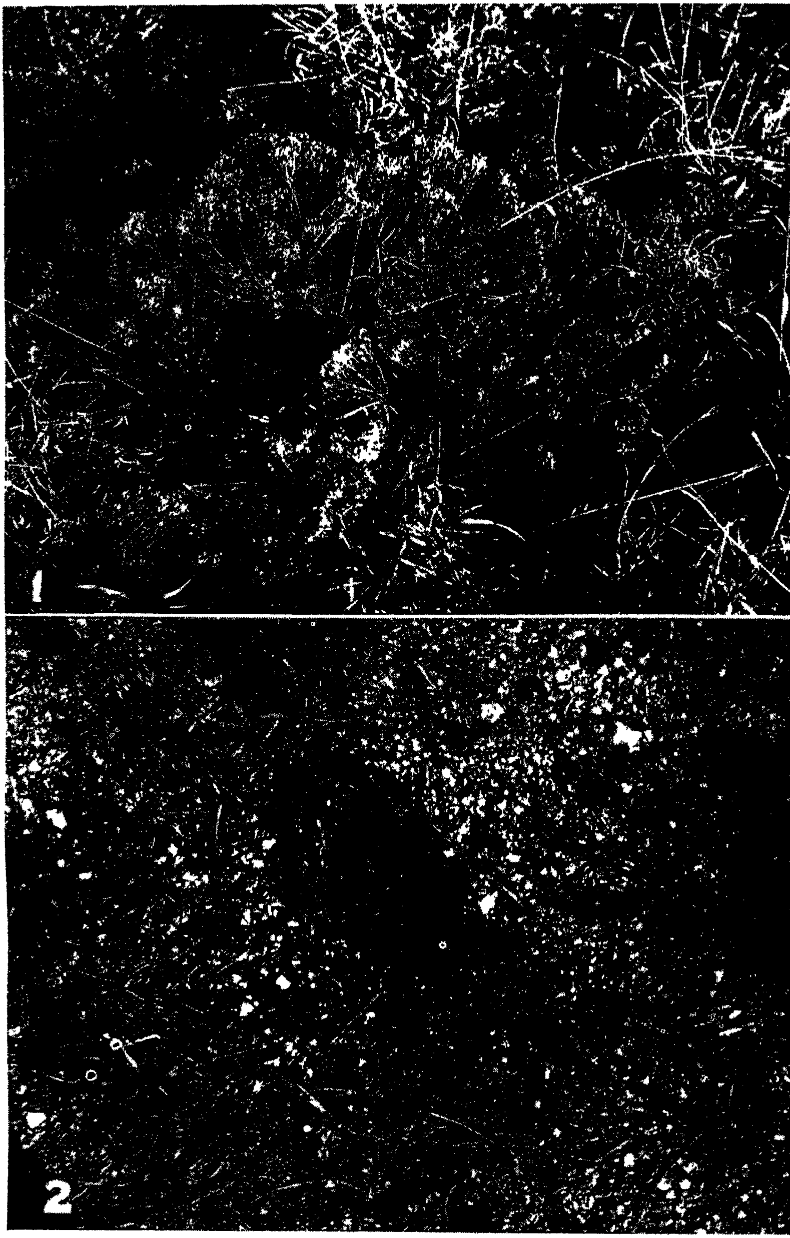
Observations during heavy snows on the college campus at Hays, Kansas, showed many shrubs had been pruned of their lower branches by cottontails, spirea (*Spirea van houttii*), lilac (*Syringa vulgaris*), and wild rose (*Rosa pratincola*) being attacked.

During the winter of 1940 after a heavy snow had fallen, cottontail rabbit pellets containing red cedar seeds and partially digested cedar fruits were found beneath the red cedar wind break on the campus. Pellets containing cedar seeds were found as much as 125 yards away from the cedars. The cedar fruits were dropped by birds feeding in the branches of the trees, making them available to the rabbits.

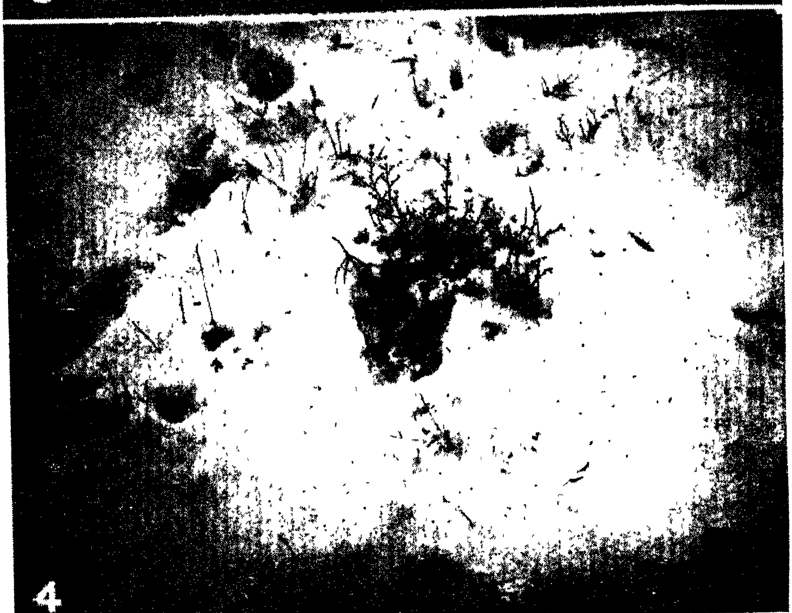
In the pasture land during heavy snows, the plants used as food by cottontails were much the same as those previously mentioned for the jackrabbit.

Seed Dispersal

An examination of several hundred rabbit pellets, both jackrabbit and cottontail, was made to determine in some measure the importance of rabbits as



1. Broom weed (Gutienezia sarothrae) which has been bitten off by rabbits and lower parts of stems eaten leaving dead flowering parts of the plants.
2. Root of blazing star which has been dug out and gnawed off by jackrabbit whose fecal pellets are in evidence.



3. A black tailed jackrabbit in its form under a clump of sand dropseed grass. Buffalo bur is shown projecting above the snow.
4. A Russian thistle which has been partially consumed by a jackrabbit during a period of snow.

agents of seed dispersal. The pellets were examined to find what seeds were passing through the digestive tracts of the rabbits without being injured.

The 473 pellets collected November 17, 1940, from four different habitats in the college pasture, Hays, Kansas, yielded the following whole seeds:

Sporobolus cryptandrus	941 seeds
Amaranthus sp.	44 seeds
Opuntia sp.	15 seeds
Panicum capillare	10 seeds

After the above seed had been placed between wet blotters for two weeks the following germination counts were obtained:

Sporobolus cryptandrus	95 seeds germinated
Amaranthus sp.	4 seeds germinated
Opuntia sp.	0 seeds germinated
Panicum capillare	3 seeds germinated

Twenty-four samplings of rabbit pellets, collected over various parts of central and western Kansas during a period of three years, were examined for seeds.

The following list indicated the species of plants whose whole seeds were found in the pellets and the number of samplings in which each species occurred:

Sporobolus cryptandrus	14 samplings
Amaranthus sp.	11 samplings
Opuntia sp.	6 samplings
Solanum sp.	2 samplings
Panicum capillare	2 samplings
Ambrosia psilostachya	1 sampling
Rumex sp.	1 sampling
Juniperus virginiana	1 sampling

The viability of the seeds found in the pellets has not been adequately tested at the present writing. Timmons and Wenger (5) found that cactus seed taken from jackrabbit pellets showed a higher per cent of germination than seed obtained from cactus fruits.

Apparently sand dropseed and pig weed are viable as shown by the germination test. This indicates that rabbits may disperse sand dropseed and be instrumental in the early appearance of this grass in areas retired from cultivation.

SUMMARY

The jackrabbits and cottontails are common residents of the Great Plains and the most numerous species of wild game.

Prickly pear cactus, broom weed, pig weed, and sand dropseed grass appear to be the favored food plants of rabbits on the range during favorable and unfavorable times.

During drought periods, forbs with succulent roots are sought out and cactus pads and fruits are eaten in large quantities.

While heavy snows covered the ground rabbits ate quantities of dried remnants of Russian thistle, buffalo bur, sand dropseed, yucca, and cottontails ate cedar berries and twigs of ornamental shrubs.

Considerable numbers of spines of buffalo bur and prickly pear were found in the pellets of rabbits.

Rabbits act as agents of dispersal for several species of plants by disseminating them in their fecal pellets, sand dropseed, prickly pear and pig weed being principal seeds observed in fecal pellets.

Germination tests indicate that some of these seeds are viable

Rabbits may have a part in the early appearance of sand dropseed in land retired from cultivation.

TABLE I. List of plants used as food by rabbits during periods of snow (S), drought (D), and normal conditions (N). The parts of the plants preferably eaten by the rabbits are also listed.

	Common Name	Technical Name	Plant Part Eaten	S	D	N
1.	prickly pear	*Opuntia sp.*	stem and fruit	x	x	x
2.	pin cush on cactus	*Neomamallaria vivipara*	stem and fruit		x	
3.	tall dropseed	*Sporobolus asper*	seed stalk	x	x	
4.	chalk lily	*Nuttallia decapetala*	rosette		x	
5.	broom weed	*Gutierrezia sarothrae*	rosettes and stem		x	x
6.	soap weed	*Yucca glauca*	leaves	x	x	
7.	sand dropseed	*Sporobolus cryptandrus*	seed stalk and stem	x	x	x
8.	switch grass	*Panicum virgatum*	seed and stalk	x	x	
9.	blue grama grass	*Bouteloua gracilis*	leaves and stems	x	x	x
10.	buffalo grass	*Buchloe dactyloides*	leaves, stems and seeds	x	x	x
11.	ill-scented sumac	*Rhus trilobata*	twigs and bark	x	x	
12.	Russian thistle	*Salsola pestifer*	dried stems	x		
13.	Serrate-leafed evening primrose	*Meriolix serrulata*	stems and rosettes	x		x
14.	blazing star	*Liatris punctata*	fleshy root, crown and stem	x	x	
15.	buffalo burr	*Solanum rostratum*	seed pods	x		
16.	pig weed	*Amaranthus sp.*	stem and seeds	x	x	x
17.	red cedar	*Juniperus virginiana*	fruit	x	x	
18.	wild lettuce	*Lactuca sp.*	rosettes	x	x	
19.	Western wall flower	*Cheirinia aspera*	rosettes	x	x	
20.	wild four o'clock	*Allionia nyctaginea*	dried stems	x		
21.	Texas sand wort	*Arenaria texana*	winter rosette			x
22.	Lavendar-leafed evening primrose	*Galpinsia lavendulaefolia*	winter stems and leaves	x		x
23.	witch grass	*Panicum capillare*	seed	x	x	x
24.	hairy dropseed	*Sporobolus pilosus*	seed stalk	x		x
25.	lambs quarter	*Chenopodium album*	dry stems	x		
26.	narrow-leafed stenosiphon	*Stenosiphon linifolius*	rosettes	x		x
27.	purple cone flower	*Echinacea angustifolia*	crown and fleshy root		x	
28.	Western sand cherry	*Prunus besseyi*	twigs	x		
29.	prairie ragweed	*Ambrosia psilostachya*	stems and seeds	x		
30.	smooth sumac	*Rhus glabra*	stem tips and bark	x		

LITERATURE CITED

1. Kansas Fish and Game. 1942. A new industry, Pub. Kansas forestry, fish and game commission, 4:2, Feb., p.2.
2. LANTZ, D. E. 1929. Cottontail rabbit in relation to trees and farm crops. U.S.D.A., Farmers' Bul., 702, May, p. 4.
3. PALMER, T. S. 1897. Jackrabbits in U. S. U.S.D.A., Division of Biological survey, Bul. 8, p. 12.
4. RIEGEL, ANDREW. 1941. Some coactions of rabbits, rodents, and cactus. Trans. Kan. Acad. of Science, vol. 44, p. 97.
5. TIMMONS, F. L. and WENGER, L. E. 1940. Jackrabbits and cactus team up. Kansas Farmer, p. 5, April 20.
6. VORHIES, CHAS. T. and WALTER P. TAYLOR. 1933. Life histories and ecology of jackrabbits in relation to grazing in Arizona. Tech. Bul. 49, University of Arizona, College of Agriculture, p. 516.

Litter Records of Some Mammals of Meade County, Kansas*

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Field parties from the University Museum of Vertebrate Paleontology worked in Meade County, Kansas in the summers of 1940 and 1941. During July and August of these two years there was so much rainfall at times that it was impossible to work on fossils. Consequently, a considerable amount of time was spent collecting and studying the recent mammals of that area. Part of the data thus obtained is presented in this paper. A general discussion of the mammals of the Meade County State Park was presented by Joe A. Tihen and James M. Sprague in "Amphibians, Reptiles and Mammals of the Meade County State Park," Trans. Kans. Acad. Sci., 42:499-511, 1939. Claude W. Hibbard and George C. Rinker published a more specific paper on "A New Bog-lemming *(Synaptomys)* from Meade County, Kansas," Univ. Kans. Sci. Bull., Vol. 28, Pt. 1, pp. 25-35. 1942. References have been drawn from both of these papers in the following discussion.

Cryptotis parva (Say). One female of this species with three embryos was taken on July 22, 1941, and a second, with five embryos, on July 25, 1941. In each case, the embryos measured approximately 10 mm. in length.

Citellus spilosoma major (Merriam). In all, five adult females of *C. s. major* were taken, three on August 3, 1941, one on August 4, 1941, and one on August 9, 1941. Of the three taken on August 3, two were carrying embryos. One of them had 8 embryos and the other 6. The female taken August 9 was captured after being ploughed up in a wheat field. With her were 4 young, two of which were captured and proved to be about two-thirds grown. Evidently two litters of young are born during the summer.

Onychomys leucogaster arcticeps (Rhoads). Only one female with embryos was taken. This specimen, taken August 9, 1941, had five embryos. A number of immature and sub-adults were taken at the same time as the female mentioned above, which indicates that that litter represented at least the second and possibly the third litter of the season. This is in accordance with the conclusion of Tihen and Sprague (op. cit.) who wrote of this species, "The grasshopper mouse in Kansas has at least two litters a season, for females bearing full time fetuses were taken June 18, and 30, 1938, and July 20, 1938, while a female bearing fetuses approximately one-fifth grown was taken July 16, 1938. Four to five young is the common number."

Reithrodontomys megalotis (Baird). One female of this species, with embryos, was taken July 19, 1941. The number of embryos in this specimen was four. They were five mm. in length. The total number of females taken was five.

Reithrodontomys albescens albescens Cary. On July 8, 1940, a female *R. a.*

*The author wishes to express his appreciation to the members of the field parties who participated in the collecting of the mammals upon which this paper is based, and to John Carlton, Leonard Sutherland, and the Kansas State Fish and Game Commission for their assistance and permission to study the Meade County State Park area. I also wish to thank Dr. Claude W. Hibbard for his assistance in the preparation of this paper.

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albescens bearing three embryos was taken. Another with four embryos was taken July 9, 1941, and a third, with five embroys, was trapped July 10, 1941. On August 13, 1941, a female was found in a nest with 3 young. The young mice did not have their eyes open, but were well covered with hair. The nest in which they were found was built of shredded buffalo grass and was about three inches in diameter. It was discovered in a burrow approximately six inches under ground among the roots of buffalo grass. The fact that the specimens with embryos and the specimen with very small young were taken a month apart indicates that more than one litter is born during the season.

Sigmodon hispidus texianus (Audubon and Bachman). Thirteen females bearing embryos were taken and one nest with young in it was found. Of the specimens with embryos, three were taken July 22, seven July 23, one July 25, and two July 28, 1941. The total length of these females ranged from 251 mm. to 312 mm. Both their size and tooth wear indicates that the females of this species become sexually mature a considerable time before they reach their full size. Also, it was noted that the testes of some of the males, which were approximately three-fourths grown, appeared to be in breeding condition. The numbers of embryos ranged from five to ten with an average of 7.38 embryos per litter. It was observed that the immature females had the fewest embryos.

The nest was found July 22, 1941, in the high, thick grass of one of the areas being trapped and contained 8 very small young. The nest was built on the surface of the ground, was about six inches in diameter, and covered over on top. The inside diameter of the nest was approximately three inches. It was constructed of dead grass and had no lining. The opening was in the side.

In view of the fact that the cotton rats were extraordinarily abundant in Meade county in 1941, it seems justifiable to give some further information concerning them here.

In regard to the occurrence of this mammal in 1938, Tihen and Sprague (op. cit.) state, "The cotton rat is present in small numbers in the high grass patches in the lowlands and transitional areas. *Sigmodon* is apparently limited to these localized areas." This situation was also the case in 1939.

During 1940 and 1941, there was a great increase in the amount of rainfall in this area, and consequently an increase in the amount of cover and food suitable to *Sigmodon*. In 1940, the cotton rat was among the most common mammals of Meade County, being, however, still restricted to the high grass patches of the lowland and transition areas of Tihen and Sprague.

By July, 1941, the number of *Sigmodon* had increased to such an extent that they were by far the most abundant species. Their run-ways could be found in almost every sort of cover, and they could be heard rustling and squeaking at all hours of the day. One could hardly drive along the roads for any distance without seeing some run across in front of him. Judging from the number caught in traps during the day, they seemed to be nearly as active in the daytime as at night.

The cotton rats occupied the lowland and transitional areas in great numbers, and the pressure of the population had become so great that they had pushed out onto the high plains area. Many were caught in the buffalo-gramma grass association, far from any other cover. They had also invaded the wheat and

barley fields on the upland and large numbers of them were seen while these crops were being harvested.

An idea of the density of the *Sigmodon* population may be got from a consideration of the number trapped in limited areas. It should be stated that these areas probably afforded optimum conditions for the cotton rat. The first area trapped was about two and one-half acres in extent. It lies on the north edge of brooder pond No. 1 in the Meade County State Park. For a complete description of this area see Hibbard and Rinker (1942). From July 7 to July 22, over two hundred *Sigmodon* were taken in the area. Seventy-six of these were caught during the first twenty-four hours of trapping.

Another area, approximately one acre in size, was trapped also. This plot lies some two hundred yards south of the one mentioned above and is on the south side of pond No. 1. Over a period of five days and nights, beginning July 21, one hundred and forty-four *Sigmodon* were removed from this area. The greater part of the approximately three hundred and forty-four cotton rats taken were sexually immature specimens.

As the cotton rats seemed to be constantly moving and active both day and night, it is impossible to say that the figures given represented the actual populations of the areas. There would certainly be a constant influx of rats into the areas where the population was being decreased, but there was no means of discovering how rapidly this movement took place.

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MEMBERSHIP OF THE ACADEMY

April 30, 1943

ABBREVIATIONS: The following abbreviations for institutions have been used:

U. of K.: University of Kansas.
K.S.C.: Kansas State College of Agriculture and Applied Science.
K.S.T.C.: Kansas State Teachers College.
F.H.K.S.C.: Fort Hays Kansas State College.
H.S.: High School.
Jr. H.S.: Junior High School.
Jr. Col.: Junior College.

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Jewell, Minna E., Ph.D., 1925, Prof. Zoology, Thornton Jr. College, Harvey, Ill.
*Johnson, Donald M., Ph.D., 1940, Instr. in Psychology, F.H.K.S.C., Hays.
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Johnson, Thaine, Student, 1942, Lindsborg; or Jamestown.
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JUNIOR ACADEMY OF SCIENCE CLUBS
*Argentine Biological Science Club of K.C., 1939, Miss Gladys Beck, sponsor, Wyandotte H.S., Kansas City.
Ben Franklin Club, 1935, Liberty Memorial H.S., Lawrence.
*College High Science Club, College H.S., Jacob Ulrich, sponsor, K.S T.C., Pittsburg.
*Einstein Club, 1943, Senior H.S., Max Barber, sponsor, Sterling.
Garden City Schools Science Club, 1942, Garden City.
Girard H S. Science Club, 1938, W. V. McFerrin, sponsor, 614 S. Cherokee St., Girard.
Independence General Science Club, 1938, Parley W. Dennis, sponsor, Independence.
Junction City H.S. Science Club, 1934, H. R. Callhan, sponsor, Junction City.
*Kaolin Science Club, 1941, Ernest Larson, sponsor, Clay County Community H.S., Clay Center.
Kensington Science Club, 1942, Kensington.
*Lawrence Junior Academy Science Club, 1932, Edith Beach, sponsor, Lawrence.
*Manhattan H S. Science Club, 1938, Ralph Rogers, Donald Parrish, and Robert Boles, sponsors, Manhattan.
Pittsburg H.S. Jr. Academy, 1938, Nell K. Davis, sponsor, Pittsburg.
*Shawnee-Mission Science Club, 1939, J. C Hawkins, sponsor, Wichita.
Salina Jr. Academy of Science, 1942, H.S., Salina.
Seaman Science Club, 1939, Laura Greene, sponsor, Seaman H.S., Topeka.
*Studiae Scientarum Science Club, 1943, Lyndon Herrman, sponsor, 702 E. 2nd St., Eureka.
*Taxidermy Club, 1938, R. W. Davee, sponsor, C.C.C.H.S., Columbus.
*Test Tube Tinkers Science Club, 1943, M. Elizabeth Boys, sponsor, Tonganoxie.
*Wichita East High Science Club, 1934, J. A. Brownlee, sponsor, 340 N. Ash, Wichita.
*Kaiser, C. Philip, B.A., 1943, Geologist, State Geological Survey, Lawrence.
Kalich, Frank V., 1940, Asst. Instr., Dept. Zoology, 203 Snow Hall, U. of K., Lawrence; or 637 Ohio, Kansas City.
Kansas City Public Library, 1930, Kansas City, Mo.
Kaufman, Clemens, M.S., 1935, Address Unknown.
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Kelly, E G., Ph.D., 1935, Extension Entomologist, K.S.C., Manhattan.
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Kreider, Leonard C., Ph.D., 1939, Chem. Dept., Bethel College, North Newton.
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*Leonard, Alice E., M.A., 1940, 1916 Louisiana, Lawrence.
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*Lockhart, Charles H., M.S., 1938, Capt. Charles H. Lockhart, 1210 N. Oregon St. 12, El Paso, Texas; or Zoology Dept., K.S.C., Manhattan.
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McCracken, Elizabeth, Ph.D., 1939, Instr. in Biology, Ohio Wesleyan Univ., Delaware, Ohio.
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Meade, Grayson E., M.A., 1942, Dept. Geo. and Paleon., Texas Tech. College, Lubbock, Texas.
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Newcomb, Margaret, M.S., 1937, Assoc. Prof. Botany, K.S.C., Manhattan.
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Smith, Cecil E., M.A., 1942, Asst. Dean, Jr. College, Pratt.
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*Wichita University Library, 1939, Univ. of Wichita, Wichita.
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NECROLOGY

The Academy announces with regret the death of the following members:

WILLIAM ASBURY HARSHBARGER. Professor Harshbarger, for over forty years professor of mathematics at Washburn College, died at Topeka, Kansas, on July 17, 1942. He was born in West Virginia in 1862, and was educated at West Virginia University, Oberlin and Washburn Colleges, and the University of Chicago. Although well-known as a teacher of mathematics, he probably had a still wider reputation in his avocation, plant breeding. Through his interest in this field, he became an intimate friend of the late Luther Burbank, and was an officer in the American Rose Society and the American Genetic Association. Many of the unusual plants and trees on the Washburn campus today remain as a memorial to Professor Harshbarger's interest in plants and their growth.

Professor Harshbarger was, for many years, an active and life member of the Kansas Academy of Science. Joining the Academy in 1903, he served at various times as vice president and as treasurer and, in 1914, he became president of the Academy. In recent years, ill health caused his retirement from active life; in 1940, he became emeritus professor at Washburn College after serving that institution since 1893.

WILLIAM HAROLD METZGER. Dr. Metzger died at Columbia City, Indiana, on July 7, 1942 after an illness of seven months. He was born in northern Indiana in 1899 and received his higher education at Purdue University, Pennsylvania State College, Kansas State College and Ohio State Unisity. Pennsylvania State College, Kansas State College and Ohio State University. With the exception of three years service as county agent in Kansas, his mature life was spent as a teacher and investigator in soil science. In 1932, he joined the staff of Kansas State College at Manhattan and continued his work at that institution until death cut prematurely short his promising career. Dr. Metzger joined the Academy in 1939. Some of his scientific work will be found recorded on the pages of these *Transactions.*

OFFICERS OF THE ACADEMY, 1869-1944

Year	President	First Vice-President	Second Vice-President	Secretary	Treasurer
1869	B. F. Mudge	J. S. Whitman		J. D. Parker	F. H. Snow
1870	B. F. Mudge	J. S. Whitman		J. D. Parker	F. H. Snow
1871	John Fraser	B. F. Mudge		J. D. Parker	F. H. Snow
1872	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F. H. Snow
1873	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F. H. Snow
1874	F. H. Snow	J. A. Banfield	J. D. Parker	John Wherrell	R. J. Brown
1875	F. H. Snow	B. F. Mudge	J. D. Parker	John Wherrell	R. J. Brown
1876	F. H. Snow	B. F. Mudge	J. H. Carruth	Joseph Savage	R. J. Brown
1877	F. H. Snow	B. F. Mudge	J. H. Carruth	Joseph Savage	R. J. Brown
1878	F. H. Snow	B. F. Mudge	J. H. Carruth	E. A. Popenoe	R. J. Brown
1879	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1880	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1881	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1882	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1883	A. H. Thompson	J. R. Mead	G. E. Patrick	E. A. Popenoe	R. J. Brown
1884	R. J. Brown	F. H. Snow	Joseph Savage	E. A. Popenoe	A. H. Thompson
1885	R. J. Brown	E. L. Nichols	G. H. Failyer	E. A. Popenoe	A. H. Thompson
1886	E. L. Nichols	J. D. Parker	N. S. Goss	E. A. Popenoe	I. D. Graham
1887	J. D. Parker	J. R. Mead	E. H. S. Bailey	E. A. Popenoe	I. D. Graham
1888	J. R. Mead	E. H. S. Bailey	T. H. Dinsmore, Jr.	E. A. Popenoe	I. D. Graham
1889	T. H. Dinsmore, Jr.	E. H. S. Bailey	G. H. Failyer	E. A. Popenoe	I. D. Graham
1890	G. H. Failyer	D. S. Kelly	F. W. Cragin	E. H. S. Bailey	I. D. Graham
1891	Robert Hay	F. W. Cragin	O. C. Charlton	E. H. S. Bailey	F. O. Marvin
1892	E. A. Popenoe	F. O. Marvin	Mrs. N. S. Kedzie	E. H. S. Bailey	D. S. Kelly
1893	E. H. S. Bailey	J. T. Willard	E. B. Knerr	A. M. Collete	D. S. Kelly
1894	L. E. Sayre	I. D. Graham	J. L. Howitt	E. B. Knerr	D. S. Kelly
1895	Warren Knaus	I. D. Graham	S. W. Williston	E. B. Knerr	D. S. Kelly
1896	D. S. Kelly	S. W. Williston	D. E. Lantz	E. B. Knerr	L. E. Sayre
1897	S. W. Williston	D. E. Lantz	A. S. Hitchcock	E. B. Knerr	J. W. Beede
1898	D. E. Lantz	C. S. Parmenter	L. C. Wooster	E. B. Knerr	J. W. Beede
1899	E. B. Knerr	A. S. Hitchcock	J. R. Meade	D. E. Lantz	J. W. Beede
1900	A. S. Hitchcock	E. Miller	J. C. Cooper	D. E. Lantz	J. W. Beede
1901	E. Miller	J. C. Cooper	L. C. Wooster	D. E. Lantz	E. C. Franklin
1902	J. T. Willard	Edward Bartow	J. A. Yates	G. P. Grimsley	E. C. Franklin
1903	J. C. Cooper	Edward Bartow	J. A. Yates	G. P. Grimsley	Alva J. Smith
1904	Edward Bartow	L. C. Wooster	B. F. Eyer	G. P. Grimsley	Alva J. Smith
1905	L. C. Wooster	F. W. Bushong	W. A. Harshbarger	J. T. Lovewell	Alva J. Smith
1906	F. O. Marvin	B. F. Eyer	J. E. Welin	J. T. Lovewell	Alva J. Smith
1907	J. A. Yates	E. Haworth	F. B. Dains	J. T. Lovewell	Alva J. Smith
1908	E. Haworth	F. B. Dains	J. M. McWharf	J. T. Lovewell	Alva J. Smith
1909	F. B. Dains	J. M. McWharf	Alva J. Smith	J. T. Lovewell	F. W. Bushong
1910	F. B. Dains	J. M. McWharf	Alva J. Smith	J. T. Lovewell	F. W. Bushong
1911	J. M. McWharf	Alva J. Smith	J. E. Welin	J. T. Lovewell	F. W. Bushong
1912	F. W. Bushong	Alva J. Smith	J. E. Welin	J. T. Lovewell	L. D. Havenhill
1913	Alva J. Smith	W. A. Harshbarger	J. A. G. Shirk	J. T. Lovewell	L. D. Havenhill
1914	W. A. Harshberger	J. A. G. Shirk	J. E. Todd	J. T. Lovewell	L. D. Havenhill
1915-1916	J. A. G. Shirk	J. E. Todd	F. U. G. Agrelius	J. T. Lovewell	L. D. Havenhill
1916-1917	J. E. Todd	F. U. G. Agrelius	L. D. Havenhill	W. W. Swingle	W.A. Harshbarger
1917-1918	F. U. G. Agrelius	L. D. Havenhill	B. M. Allen	W. W. Swingle H. W. Swingle Guy West Wilson	W.A. Harshbarger
1918-1919	L. D. Havenhill	R. K. Nabours	B. M. Allen	Guy West Wilson	F. C. Bruchmiller
1919-1920	R. K. Nabours	B. M. Allen	O. P. Dellinger	E. A. White	L. D. Havenhill
1920-1921	O. P. Delinger	Roy Rankin	W. P. Hays	E. A. White	L. D. Havenhill
1921-1922	Roy Rankin	R. K. Nabours	W. R. B. Robertson	E. A. White	L. D. Havenhill
1922-1923	R. K. Nabours	H. P. Cady	H. H. Nininger	E. A. White	L. D. Havenhill
1923-1924	H. P. Cady	H. H. Nininger	J. E. Ackert	E. A. White	L. D. Havenhill
1924-1925	H. H. Nininger	J. E. Ackert	F. U. G. Agrelius	E. A. White	L. D. Havenhill
1925-1926	J. E. Ackert	H. M. Elsey	W. M. Goldsmith	E. A. White	L. D. Havenhill
1926-1927	H. J. Harnly	Mary T. Harman	L. D. Wooster	E. A. White	L. D. Havenhill
1927-1928	Mary T. Harman	L. D. Wooster	W. B. Wilson	E. A. White	L. D. Havenhill
1928-1929	L. D. Wooster	W. B. Wilson	Hazel E. Branch	G. E. Johnson	L. D. Havenhill
1929-1930	W. B. Wilson	Hazel E. Branch	W. M. Goldsmith	G. E. Johnson	R. Q. Brewster
1930-1931	Hazel E. Branch	Roger C. Smith	W. H. Matthews	G. E. Johnson	R. Q. Brewster
1931-1932	Roger C. Smith	W. J. Baumgartner	J. W. Hershey	G. E. Johnson	R. Q. Brewster
1932-1933	Robert Taft	J. W. Hershey	W. H. Matthews	G. E. Johnson	H. A. Zinszer
1933-1934	J. W. Hershey	W. H. Matthews	E. A. Marten	G. E. Johnson	H. A. Zinszer
1934-1935	W. H. Matthews	E. A. Marten	W. J. Baumgartner	G. E. Johnson F. C. Gates.	H. A. Zinszer
1935-1936	W. J. Baumgartner	L. Oncley	H. H. Hall	Roger C. Smith	H. A. Zinszer
1936-1937	L. Oncley	G. A. Dean	W. H. Schoewe	Roger C. Smith	H. A. Zinszer
1937-1938	G. A. Dean	W. H. Schoewe	J. H. Hall	Roger C. Smith	H. A. Zinszer
1938-1939	W. H. Schoewe	H. H. Hall	E. O. Deere	Roger C. Smith	H. A. Zinszer
1939-1940	H. H. Hall	E. O. Deere	F. C. Gates	Roger C. Smith	H. A. Zinszer
1940-1941	E. O. Deere	F. C. Gates	R. H. Wheeler	Roger C. Smith	H. A. Zinszer
1941-1942	F. C. Gates	R. H. Wheeler	H. A. Zinszer	John C. Frazier	F. W. Albertson
1942-1943	R. H. Wheeler	H. A. Zinszer	L. D. Bushnell	John C. Frazier	F. W. Albertson
1943-1944	H. A. Zinszer	L. D. Bushnell	J. W. Breukelman	John C. Frazier	F. W. Albertson

NOTE.—Previous to 1931-'32 the secretary was also editor of these *Transactions*. From 1931 until 1941, F. C. Gates was editor.

Recent and Present Members of the Kansas Academy of Science in the Armed Forces and Defense Work*

Allen, Merle W., Jr. College, Coffeyville, Kansas. (Army)
Barker, Benjamin W., St. Louis, Mo. (Defense work)
Bennett, Dewey, Jr. College, Garden City. (Navy)
Bice, Claude W., Northern Regional Research Laboratory, 526 Nowland Avenue, Peoria, Illinois. (Defense work)
Bishop, Francis, U. of K., Lawrence. (Army)
Boertman, C. Stewart, K.S.T.C., Emporia. (Army)
Boles, Paul, K.S.C., Manhattan. (Army)
Branson, Farrel A., F.H K.S.C., Hays; Coats. (Navy)
Branson, Jack W., Belleville. (Marines)
Branson, Lester, Coats. (Army)
Brigden, Robert L., Naval Aviation Cadet Selection Board, New Orleans, La. (Navy)
Briggs, Leslie, F.H.K.S.C., Hays. (Army)
Butler, John Earl, Stockton. (Army)
Byrn, John S., Falun. (Army, Division of Meteorology)
Carlsson, Laurel, 1108 N. 19th, Kansas City, Kansas. (Defense work)
Cressler, Lawrence, 348 N. Ash, Wichita. (Defense work)
Davis, Louis K., 249 N. 8th St., Salina. (Army)
Delavan, Wayne, R.R. 2, Box 61, Bronson. (Army)
Deyoe, C. F., 408 West 4th St., Hays; Jetmore. (Navy)
Dill, Florence E., U. of K., Lawrence. (Defense work)
Downs, Theodore, K.S.T.C., Emporia. (Army)
Durell, W D., Govt. Landscape Works, Norfolk, Va. (Defense work)
Ericson, John, 835 Lindenwood, Topeka. (Defense work)
Everhart, Marion, Brownell. (Navy)
Fergus, C. L., 1122 Ohio, Lawrence. (Navy)
Gates, D. M., University of Michigan, Ann Arbor, Mich. (Defense work)
Goff, Richard, 1215 Waverly Avenue, Kansas City, Mo. (Defense work)
Goodwin, Ralph, F.H.K.S.C., Hays. (Navy)
Gray, W. H., K.S.T.C., Emporia. (Army)
Green, Morton, U. of K., Lawrence; 100 Woodruff Avenue, Brooklyn, N. Y. (Army)
Griffith, M. E., Fargo, N D (Navy)
Grover, L. L., F H.K S.C., Hays; Stockton. (Navy)
Groverman, L. J., 1115 Ohio Street, Lawrence. (Navy)
Hancock, H. R., Troy. (Army)
Hase, C. L., F H K S C., Hays; Selden. (Army)
Heckert, L C., 109 W. Jackson, Pittsburg. (Defense work)
Hellmer, Leo E., Wichita Guidance Center, Wichita. (Army)
Hemphill, John, F.H.K.S C., Hays; Byers. (Army)
Hoagland, Darrell, F.H.K S.C , Hays; Jetmore. (Army)
Hopkins, Harold, F H.K.S.C., Hays. (Navy)
Jeffords, R. M., Water resources Branch, U S. Geological Survey, Washington, D. C. (Defense work)
Johnson, D M., F.H.K.S.C., Hays (Army)
Johnson, Thame, Jamestown. (Defense work)
Kirkpatrick, E. L., Apt. 4, 3964 Nichols S. W., Washington, D. C. (Defense work)
Kissinger, L. L., F.H K.S.C., Hays. (Army)
Lacey, Marvin, F.H.K.S.C., Hays, Bison. (Coast Guard)
Lehman, Joe Jr., Versailles, Mo. (Army)
Lippert, Robert D., Bison. (Navy)
Lunestrom, Leon, Lindsborg. (Army)
McNary, T. H., 321 S. Crestway, Wichita. (Defense work)
Mackintosh, David L , K S.C., Manhattan. (Army)
Matheny, W. G., F H.K.S.C , Hays; Russell Springs. (Army)
Mentzer, Loren, K S.T C., Emporia. (Army)
Mikesell W H . U. of Wichita, Wichita. (Army)
Moore, R. C , U. of K., Lawrence; Rm 1243 Temp. "g" Bldg., 23 St. N. W., War Dept., Washington, D. C. (Army)
Nagge, J. W., K.S T.C., Emporia. (Army)
Olson, Donald, Cuba. (Defense work)
Olson, Erwin T., Lindsborg. (Defense work)
Orr, Tom G., 5930 Mission Drive, Kansas City Mo. (Army)
Patton, Leo W., Southwestern College, Winfield; Sublette. (Army)
Peterson, William, Selkirk, N. Y. (Army)
Peppler, H J., K S.C., Manhattan. (Army)
Plum, W. B., Southwestern College, Winfield. (Navy)
Porter, John McGill, Concordia (Navy)

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*By action of the Academy at its 75th meeting, it was voted to publish a list of all members of the Academy contributing directly to the war effort. The list as printed contains all information available on such individuals up to August 1, 1943. Additions and corrections should be sent to the secretary of the Academy, Dr. J. C. Frazier, Manhattan, Kansas.

Price, Edwin O., Army Air Forces Field, Fort Worth, Texas. (Army)
Rinker, G. C., U. of K., Lawrence; Hamilton. (Army)
Roemer, Raymond F., F.H.K.S.C., Hays; Gove. (Navy)
Rohrs, Herman E., F.H.K.S.C., Hays. (Army)
Schoonhoven, Paul A., 615 N. Delaware, Manhattan. (Army)
Schraeder, Leo, F.H.K.S.C., Hays; Timken. (Navy)
Schraeder, Quentin, 438 S. College Avenue, Salina. (Defense work)
Schumann, Margaret, U. of K., Lawrence. (Defense work)
Senter, C. H., Junior College, Pratt. (Navy)
Sergeant, Tom, Cedarvale. (Army)
Solomon, Marvin, K.S.T.C., Pittsburg. (Army)
Stevens, Edward, K.S.T.C., Pittsburg; Columbus. (Army)
Stevens, Evan, U. of K., Lawrence; Independence. (Army)
Tarrant, Ansel, F.H.K.S.C., Hays; Bucklin. (Army)
Taylor, William Ralph, U. of K., Lawrence. (Army)
Tomanek, Gerald, F.H.K.S.C., Hays; Collyer. (Navy)
Voth, Henry W., U. of K., Lawrence; Hillsboro. (Army)
Wallace, Maurice, West India Oil Co., Ecuador. (Defense work)
Webb, John, 1201 Settles Ave., Big Springs, Texas. (Navy)
Wood, Robert E., H.S., Lawrence. (Defense work)
Zinszer, W. Karl, 194 Oak Court, Palo Alto, Calif. (Defense work)

The Seventy-Fifth Anniversary of the Kansas Academy of Science

The seventy-fifth anniversary of the Academy was commemorated at the annual banquet, Saturday evening, April 10, 1943, in the Kansas Room of the Union Building at the University of Kansas. According to tradition, President-elect Harvey Zinszer was toast-master. The local committee made a large symbolic birthday cake which occupied a conspicuous place in the center of the table throughout the meal, although it had originally been planned to have a large genuine cake to be cut by the oldest life member present.

Mr. I. D. Graham, who joined the Academy in 1879, hoped to be present but circumstances finally prevented his coming. A small cake with three candles on it—each candle symbolizing 25 years of the Academy—was brought in to Dr. Julius T. Willard, who joined the Academy in 1883. An honorary member, Dr. Elmer S. Riggs, formerly of the University of Kansas but for many years associated with the Field Museum in Chicago and recently returned to the University, was then introduced. Dr. Willard spoke for the life members present and President Raymond H. Wheeler responded for the Academy and then read many messages from honorary and life members who were unable to attend the meeting.

The great changes that have taken place in both the social and scientific life of the state during these past seventy-five years were so ably, in some cases, so poignantly recalled by these older members that their recollections constitute in themselves important historic and human documents. For this reason we publish pertinent portions from the letters received, prefacing these extracts with the brief address given by Dr. Willard. (After each member's name, for those quoted below, is given the date of original membership in the Academy.)

GREETINGS BY DR. J. T. WILLARD (1883),
Kansas State College, Manhattan

Mr. Toastmaster, Chancellor Malott, Mrs. Malott,
Members of the Academy and Friends:

I presume that I am on this program because of being one of the senior members of the Academy. Prof. G. H. Failyer and Sec. I. D. Graham have been members the longest time of any of us, joining in 1879. Though in his ninety-fourth year, Professor Failyer is vigorous mentally and active physically. Only deafness limits his participation in public programs. Secretary Graham, who was expected here this evening, is in his eighty-seventh year, and is still active as chief clerk in the office of Hon. J. C. Mohler, secretary of the Kansas State Board of Agriculture. I am number three in seniority, having become a member in 1883, sixty years ago.

Sixty years is a long time, and many observations have been made of the Academy and its members. As we have a long program this evening, there is no time for extended remarks from me. I have seen growth when there was only one program, with perhaps some difficulty in filling it, to the present

situation when we meet in seven sections, besides the sessions of two affiliated societies. In the early days the sciences themselves were much more elementary, and a scientific man could be interested, and to a certain degree competent, in a wider range of knowledge than is now possible.

At one time there was some difficulty in getting papers presented because of the desire that prompt publication should be made in recognized scientific journals so as to protect priorities. The increase in scientific research has been such that in spite of this difficulty interesting and informative programs have been the rule. The Academy has become especially valuable as a channel through which those just beginning scientific careers may reach the public. Establishment of the Junior Academy with its constituent branches has also contributed much toward this end.

But although the papers presented at the sessions of the Academy have been interesting and valuable, to me the chief value of the meetings has been the bringing together of the science men of the various educational institutions of the state, that they may become acquainted, and many lifelong friendships originated in that way. I have attended nearly every meeting of the Academy for sixty years, but I have not been impelled to this by the advance announcement of anybody's paper, but by the fact that I could count on renewing friendships with Snow, Lovewell, Bailey, Sayre, Haworth, Williston, Dyche, Harnly, Yates, Wooster, Marvin, Franklin, Dains and others of the last century, and to make contact with the younger ones who are too numerous to name and whose number has prevented knowing more than a fraction of them well. But it is to these younger and youngest men and women that the Academy is indebted for its current rating. So I stand here as a sample of the old life members, and a sort of symbol of the bygone days, but glad to greet those who embody the strength and spirit of the generation which will carry the Academy from this seventy-fifth anniversary to its one hundredth.

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I am well started on my 94th year and have absolutely lost my hearing and seldom attend meetings of any kind; so, I think it not prudent for me to go to Lawrence. It would be a pleasure to attend the meeting and yet I would feel sad to miss so many of the once familiar faces and smiling greetings from Mudge, Snow, Popenoe, Lovewell, Patrick, Bailey, Kellerman, Nichols, Hay, Sayre, Cragin, Meade, the Savages; all are gone. The same is true of younger members to a large extent: Dyche, Willard, the Franklins, Knaus. I joined the Academy in 1878; Graham in 1879; Willard a few years later. In so far as I know, we three are all of the old timers left. Most of these old timers are not known even by name to many present members. May the Kansas Academy of Science "Live Long and Prosper".

Cordially yours,
George H. Failyer (1878), Manhattan, Kansas

★ ★ ★

Memory carries me back to the days, sixty-four years ago, when I became a life member of the Kansas Academy of Science, and thru the years, to the enormous advances that have been made in scientific achievement. I remember reading an article by a noted geologist of that day, in which he stated that "no true bituminous coal had ever been found west of the Missouri River, and probably none exists in Kansas." Now Kansas is a coal state.

I remember that the telephone was less than three years old; we had no incandescent electric lights, cream separators, trolley cars, linotypes, cash registers, adding machines, aluminum, photographic films, motion pictures, automobiles, X-ray, liquid air, aeroplanes, color photography, machine guns, radio or Coca-Cola, nor even synthetic rubber, which we hope to have. And while all laudation must go to the Great Creator for the land, it is also true that Kansas is entirely man-made, and in this wonderful creation scientists have had a potent influence, and to the Kansas Academy I extend enthusiastic congratulations on an active life during three-fourths of a century which has outdistanced in achievement all previous history.

Sincerely yours,
I. D. Graham (1879),
Kansas State Board of Argiculture, State House, Topeka

* * *

I am glad to belong to an organization that has done its share towards the increase of the sum total of knowledge available for humanity. As a farmer I have always tried to use the latest information available in my work. Greetings to you all and may your work prosper in the future as in the past.

Yours sincerely,
A. M. Nissen (1888), Wetmore, Kansas

* * *

It would give me great pleasure to attend the meeting, but as that will be impossible, I ask you to express to the Academy my greetings and my sincerest interest in the organization.

Very truly yours,
R. B. Dunlevy (1896),
Southwestern College, Winfield, Kansas

* * *

It is with sincere regret that I find I cannot attend this meeting. Among my very pleasant memories is the connection with the Academy years ago, and I have on my library wall a photograph of the secretary's office in the State House at Topeka when I was secretary. The Academy may be well proud of its seventy-five years' record—one of the oldest in the country. I have been away from Kansas 37 years and lived there nine years when I was a young man, and to this day I am a loyal Kansan, proud of that state and its splendid Academy of Science. I send my kind regards and best wishes both to those of my old-time friends, and to those who have come after, to the officers and members of the Academy.

Very sincerely,
George P. Grimsley (1896),
Baltimore and Ohio Railroad, Baltimore, Md.

* * *

It is 46 years since I became a member of the Academy and 37 years since I was honored with the presidency. Unless I am mistaken, I am next in point of service to Professor Willard who must be the senior living past president of the Society. In 1940 I was retired as head of the Department and made Professor of Chemistry and Chemical Engineering, Emeritus, remaining in

Iowa City and doing some work in the Department. It is my hope and expectation that you will have a successful meeting, and I wish you would extend my regards to all.

Very truly yours,
Edward Bartow (1897), Iowa City, Iowa

* * *

Nothing would please me better than to attend your meeting, for I have always watched the progress of the Kansas Academy for it has accomplished many things that we here have never reached, although we have talked about them endlessly. But my job keeps me here. My four years in Lawrence, 1895-1899, were among the happiest and most interesting in my whole career, and for many years I longed to be back on Mount Oread. May your Academy, which is also mine, flourish in the future as it has in the past, as a center where enlightened men and women may help to spread the much-needed light.

Sincerely and Fraternally,
George Wagner (1897),
Professor of Zoology, University of Wisconsin, Madison

* * *

My life membership in the Kansas Academy of Science is a source of great pride to me as well as the fact that my father and step mother, B. B. Smyth and Dr. Lumina C. R. Smyth, both deceased, were enthusiastic contributing members of the Academy. I look forward with great anticipation to the day when I can again attend Academy meetings and renew acquaintance with the older members, many of whom I remember most warmly. May I offer my highest congratulations to the Academy and to its individual members, on the occasion of its 75th Anniversary, and the wish and hope that it may continue to prosper through the years to come as a potent force in the scientific upbuilding of the national character and a reservoir of knowledge and inspiration to those of our commonwealth who aspire to a higher and nobler appreciation of the wealth and power of Nature and Truth as bulwarks of Democracy.

Very sincerely yours,
E. Graywood Smyth (1901),
Consulting Entomologist, Glen Ellen, California

* * *

I regret that it is impossible for me to attend the Academy of Science dinner this evening. It would be a pleasure to meet the life-members present as well as the younger generation that are carrying on the traditions of the past. With most cordial wishes for the continued success of the Academy and its members.

Most sincerely,
F. B. Dains (1902),
University of Kansas, Lawrence, Kansas

* * *

It is a source of regret to me that pressure of work at home prevents me from journeying to Lawrence to take part in the seventy-fifth annual meeting of the Kansas Academy of Science. It would afford me much pleasure to participate in this meeting and to reflect upon the long list of contributions

which have been presented at its meetings and printed in its Proceedings, many of the volumes of which I have read.

Scientific societies represent one of the most purposeful and admirable types of human institutions. They stimulate thought, experimental inquiry, and interpretation of natural phenomena, while affording excellent opportunity for fostering intellectual companionship. Humankind has been greatly blessed by the achievements of learned societies. The Kansas Academy of Science has a history to be proud of. It is an ornament to the State of Kansas.

It has been a source of unusual satisfaction to me that the Academy saw fit to enroll me among its honorary members. Each year as the volumes of Transactions have come to my desk I have enjoyed perusing them. I send my greetings to its present members and hope that in the future it may be able to maintain the high standards which have characterized its first seventy-five years.

Sincerely,
E. V. McCollum (1902),
The Johns Hopkins University, Baltimore, Md.

* * *

Please convey to the membership of the Academy, and particularly to those who may remember me, my warmest greetings on this occasion of our diamond anniversary meeting.

Sincerely yours,
Theo. H. Scheffer (1903),
Collaborator, U. S. Biological Survey, Puyallup, Washington

* * *

I have always taken much satisfaction in being a member of the Kansas Academy of Science. Perhaps you would be interested to know some of the antecedent incidents which culminated in my coming a member.

I came to Kansas in 1882 when I was just 20 years old to teach the "natural sciences" in a small private school with limited means. I was eager but I knew my deficiencies; much of my teaching was learning and most of it was done in the outdoors and in self-constructed laboratories. Each day's learning began before 6 in the morning and ended somewhere near midnight. The text-books were "nature" and Steele's and Lind's laboratory guide my vade mecum. I made practically all the apparatus the night before to be used to illustrate the subject in class the next day. I had great enthusiasm in my students, among them are the following who have achieved more or less fame: Ed Slossen, Will Stacey, Dr. Ed Baumgartner, A. M. Nissen. They acquired this not from what they got from me—I only started them and in that I take much pardonable pride.

My earlier interest in general science led me to join the Topeka Academy of Science, which was dissolved, I think about 1900, and then I joined the Kansas Academy of Science. In the Topeka Academy I sat under the inspiring tutelage of Professors Lovewell, Craigin, Grimsley and Harshbarger of Washburn, Dr. A. H. Thompson and B. B. Smyth. But my practice and study of medicine demanded more and more of my time and energy and specialization was forced upon me. I am delighted to know that Kansas stands out so

prominently in the world of science through its Academy, and I feel greatly honored to be one of its members.

Yours sincerely,

C. F. Menninger, M.D. (1903),
The Menninger Clinic, Topeka, Kansas

* * *

I suppose no matter how long I remain away from Kansas it will always be the same, for it seems more like home to me than any other place. I should like so much to be with you and to help celebrate the seventy-fifth anniversary. I recall so very well early meetings and the men who were in attendance—Williston, Blake, Newson, Marvin, Bailey, Sayre—all now gone. I am sending you my very best wishes and the hope that everything goes off well. Although I am Emeritus Professor at Penn I have been called upon to take the headship of the Department here at Swarthmore for the duration.

With thanks and best wishes I remain

Sincerely yours,

C. E. McClung (1903),
Swarthmore College, Swarthmore, Pennsylvania

* * *

Remembering the many interesting sessions we have attended together, I send cordial greetings to the Kansas Academy of Science and sincere regrets that I am not able to be present this year.

Cordially yours,

H. P. Cady (1904), Lawrence, Kansas

* * *

When in 1870, I arrived in Kansas per movie wagon, the Academy had already hitched its wagon to a star and it has kept it firmly yoked there ever since. So I appreciate all the more the courtesies your Institution has shown me since they came from one of such age and glory. In your Reports, I note that the Academy continues to give a share of its attention to science of especially local significance. I have greatly enjoyed that part of your publications and I believe such local things are of great value. They are part of greater themes and a part which comes from those who know the ground and love it.

Perhaps we will all have more time for histories, natural and otherwise, in the good time coming when the present hurly-burly is done; when we can look back on it as among "the old, far-off unhappy things and battles long ago". I send my best wishes for a pleasant celebration and my regrets that I cannot be with you.

M. A. Barber (1904), Memphis, Tennessee

* * *

Greetings to the Kansas Academy of Science.

I write to congratulate you on keeping the Lamp of Science burning brightly in Kansas during all these years. The work you do and have done is an essential part of our civilization and it is to preserve such things that we are fighting. There are indications that at the present time, there is urgent need to prevent the desecration and diminution of our cultural agencies, due to the

pressure of war. It is not realized by all that such influences are essential for the sanity and progress of our country.

Yours sincerely,

Theo. D. A. Cockerell (1908),
Palm Springs Desert Museum, Palm Springs, California

★ ★ ★

The Academy has had a wonderful record during these years and has had as its members some of the outstanding scientists of the world. Its influence has been fine in encouraging the development of science. During my early scientific career, I was greatly stimulated by my contacts with the Academy Please extend to all the members my best wishes for the continuation of the success of the Academy.

Sincerely yours,

E. R. Weidlein (1911), Director,
Mellon Institute of Industrial Research,
University of Pittsburgh.

★ ★ ★

Please accept greetings to each member of the Academy from one for whom each year can only increase my debt to the Academy for inspiration and encouragement in scientific endeavor.

Very sincerely yours,

Edwina A. Cowan (1929),
430 South Seneca, Wichita, Kansas

★ ★ ★

I suppose that I am one of the youngest Life Members of the Academy, having passed 38 on my last birthday. I am much interested in the affairs of the Academy. From my contact with members and the perusal of the *Transactions,* it is evident that the past 75 years have been marked by substantial accomplishment. I feel that the future holds even greater opportunities for progress and for service. With best wishes, I am,

Very sincerely yours,

Charles E. Burt (1932),
Southwestern College, Winfield, Kansas

★ ★ ★

I shall certainly be with the Academy in spirit if not in person. I have always enjoyed the meetings that I have attended and the association with the friends made at these times. All have been so nice to me. I have always looked forward to seeing my friends when I arrive at the meetings as though they were childhood friends. Best wishes for the best meeting ever. I know it will be a busy one—everything crowded in one day.

Sincerely,

Otilla A. Reagan (1937),
Brigham Young University, Provo, Utah

PROGRAM OF THE SEVENTY-FIFTH ANNUAL MEETING, LAWRENCE, KANSAS

Saturday, April 10, 1943

9:00 a.m. Section Meetings:

Biology Teachers Section, Snow Hall, Room 502.

Botany Section, Snow Hall, Room 417.

Chemistry Section, Chemistry Bldg., Room 201.

Entomological Session, Entomology Dept., Snow Hall.

Geology Section, Snow Hall, Room 206.

Mathematics Session (Joint Session of Mathematical Societies). Note: This session convenes at 9:30 a.m., Frank Strong Hall, Room 9.

Physics Section, Blake Hall, Room 210.

Psychology Section, Frank Strong Hall, Room 21.

Zoology Section, Snow Hall, Room 101.

12:00 noon Lunch: Union Building Cafeteria. 1943 committees are to meet and conduct business at this time.

1:30 p.m. Symposium on Science and the War Effort. Snow Hall, Room 101.

Relation of Bacteriology and Medicine to the War Effort. Dr. Noble P. Sherwood, U. of K.

Relation of Geology to the War Effort. Dr. John C. Frye and C. Philip Kaiser, State Geological Survey.

Relation of Chemistry to the War Effort. Dr. John W. Green, K.S.C.

Relation of Botany to the War Effort. Dr. Paul B. Sears, Oberlin College.

Relation of Entomology to the War Effort. Dr. H. B. Hungerford, U. of K.

Five-minute intermission.

Relation of Food to the War Effort. Dean L. E. Call, K.S.C.

Relation of Psychology to the War Effort. Dr. H. B. Reed, F.H.K.S.C.

Relation of Zoology to the War Effort. Dr. John Breukelman, K.S.T.C., Emporia.

Relation of Physics to the War Effort. Dr. J. Howard McMillen, K.S.C.

1:45 p.m. Business of Kansas Section Mathematical Association of America. Frank Strong Hall, Room 9.

2:00 p.m. Afternoon Joint Session, Kansas Section Mathematical Association of America and Kansas Association of Teachers of Mathematics.

4:00 p.m. Business Meeting. Snow Hall, Room 101.

6:00 p.m. Banquet. Union Building, Kansas Room.

7:45 p.m. Public Lecture by Dr. Paul B. Sears, Head, Dept. of Botany, Oberlin College, Oberlin, Ohio. Hoch Auditorium. Subject: "Ecology of Peace."

Biology Teachers

Chairman, SHERMAN B. GRISWOLD

9:00 a.m. to 12:00 noon, Snow Hall, Room 502

1. Field Trips and their use in Teaching Biology. H. Ray Brown, Moundridge High School. 10 min.
2. The Construction and Use of Apparatus for Microphotography. C. T. Brandhorst, Concordia Teachers College, Seward, Nebr. 10 min.
3. The Technique of Color Photography. Andrew Riegel, F.H.K.S.C. 15 min.
4. The Preparation of Skeletons and Skins for Display. Claude W. Hibbard, U. of K. 15 min.

Botany

Chairman, ANDREW RIEGEL

9:00 a.m. to 12:00 noon, Snow Hall, Room 417

1. Kansas Botanical Notes, 1942. F. C. Gates, K.S.C. 5 min.
2. Prairie Studies in West Central Kansas, 1942. F. W. Albertson, F.H.K.S.C. Lantern. 10 min.
3. The Witches' Brooms of Spruce and Fir. S. M. Pady, Ottawa U. Lantern. 10 min.
4. Root Systems of Burley Tobacco. L. J. Gier, William Jewell Col., Liberty, Mo. Lantern. 7 min.
5. The Root System of Russian Knapweed, *Centaurea picris*. John C. Frazier, K.S.C. Lantern. 8 min.
6. Microbiological Studies on the Effect of Straw Used as a Mulch. T. M. McCalla, Soil Conservation Service, Lincoln, Nebr. 10 min.
7. A study of the Relationship Existing Between Certain Insects and Some Native Western Forbs and Weedy Plants. C. T. Brandhorst, Concordia Teachers College, Seward, Nebr. 10 min.
8. The Effect of Growth Stage and Clipping on the Chemical Composition of Blue Grama Grass (Bouteloua gracilis). Noel R. Runyon, F.H.K.S.C.
9. A Comparative Study of Sources of Seed Blue Grama Grass and the Establishment of Their Respective Seedlings Under Different Field Treatments at Hays, Kansas. Andrew Riegel, F.H.K.S.C. Lantern. 8 min.
10. Germination Tests on Four Species of Sumac. Ivan L. Boyd, Baker U. Lanter. 5 min.
11. Results in Reclamation of Strip Pit Land in Southeastern Kansas. H. H. Hall, K.S.T.C., Pittsburg. Lantern, 7 min.
12. A Few Plants New to Kansas Collections. W. H. Horr and Ronald McGregor, U. of K. (By title)
13. Concerning the Elasticity of Certain *Equisetum Rhizomes*. Otto Treitel, Nashville, Tenn. (By title)
14. Microbial Metabolism of Esters and Their Components. H. J. Peppler, K.S.C. Dept. of Bacteriology. (By title)
15. Advantage of Liquid Media in Routine Isolation of Pathogenic Fungi. H. J. Peppler, Fitzsimons General Hospital, Denver, Colo. (By title)

Chemistry

Chairman, J. WILBERT CHAPPELL

9:00 a.m. to 12:00 noon, Chemistry Building, Room 201

1. Ammonalysis of Hexavalent Chromium Derivatives. Harry H. Sisler, U. of K. Lantern. 10 min.
2. The Effect of Growth Stage and Clipping on the Chemical Composition of Buffalo Grass (Buchloe dactyloides). Noel R. Runyon, F.H.K.S.C. 10 min.
3. The Effect of Wetting Agents in the Electro-deposition of Silver from Solutions of Silver Nitrate. Edwin Hiebert and Robert Taft, U. of K. Lantern. 10 min.
4. The Colorimetric Estimation of Iodides in Stabilized Iodized Salt. L. A. Enberg, The Carey Salt Co., Hutchinson, Kansas. Lantern. 15 min.
5. Some Derivatives of Sulfanilamide. George Duerksen and R. Q. Brewster, U. of K. 10 min.
6. The Reaction of Various Phenols with Tertiary Butyl Chloride. Stanley D. Burket and R. Q. Brewster, U. of K. 10 min.
7. On the Nature of Complement. M. Gerundo, U. of S. Dakota, and Allen Gold, Lattimore Laboratories, Topeka. 5 min.
8. Study of Forssman Antigen-antibody Complexes in Rabbit's Blood. M. Gerundo, U. of S. Dakota and Allen Gold, Lattimore Laboratories, Topeka. 5 min.
9. Preparation and Properties of Anhydrous Aluminum Acetate. Arthur W. Davidson, U. of K., and John Kilpatrick, U. of California. Lantern. 10 min.
10. Isomerism in the Lactones Related to Cyclohexanol - 2 - acetic acid and Cyclohexanone - 2 - acetic acid. C. A. Vander Werf, U. of K. 10 min.
11. Milk Curd. II. Changes in Consistency during Lactation. Arthur W. Barton, F.H.K.S.C. 7 min.
12. Demonstrations of Effects of Electrostatic Forces on Soil Samples from the High Plains. Ashton Keith, Institute of Sciences, K. C., Mo. Lantern. 15 min.
13. Magnesium: Its Manufacture and Fabrication William K. Zinszer, Permanente Metals Corporation, Manteca, California. (By title)

Geology

Chairman, H. T. U. SMITH

9:00 a.m. to 12:00 noon, Snow Hall, Room 206

1. A Pleistocene Fauna from Lincoln County, Kansas. Claude W. Hibbard, U. of K. 10 min.
2. Magnesium Content of Kansas Oil Field Brines. W. H. Schoewe, U. of K. 10 min.
3. The Occurrence of *Eucastor* in the Pliocene of Trego County, Kansas. Claude W. Hibbard, U. of K. 5 min.
4. Kansas Clays and Their Ceramic Value. Norman Plummer, Kans. State Geol. Surv. 10 min.
5. Map Making from Aerial Photographs. H. T. U. Smith, U. of K. 10 min.

6. Fossiliferous Nodules of the Haskell Horizon. Arthur Bridwell, Baker U. 10 min.
7. Arcuate Structures of Type One Formed by Shrinking Spherical Surfaces. B. Ashton Keith, Kansas City, Mo. 10 min.
8. A Neglected Anatomical Feature of the Foxhall Jaw. Loren C. Eiseley, U. of K. (By title)
9. Racial and Phylogenetic Distinctions in the Interfrontal-interangular Index. Loren C. Eiseley, U. of K. (By title)
10. Romance of the Coal Lands of Southeastern Kansas. H. H. Hall, K.S.T.C., Pittsburg. (By title)

Kansas Entomological Society

Nineteenth Annual Meeting

H. B. Hungerford, *President;* Raymond Roberts, *Vice-President;*
D. A. Wilbur, *Sec.-Treas.*
Entomology Dept., U. of K., Lawrence, Kansas

Business Meeting 10:00 to 11:00 a.m.
Presentation of Papers 11:00 a.m.

1. The Fly Resistance of Pawnee Wheat. R. H. Painter, K.S.C.
2. Some Interrelations of Wheat and Hessian Fly Attack. R. H. Painter, K.S.C.
3. Some African Insects of Interest to the Medical Entomologists. H. B. Hungerford, U. of K.
4. The Probable Number of Insects in Kansas. R. C. Smith, K.S.C.
5. The Genus Eurytoma in Mexico. R. E. Bugbee, F.H.K.S.C.
6. Availability of Insecticides. Geo. A. Dean, K.S.C.
7. The Southwestern Corn Borer in Kansas. H. R. Bryson, K.S.C.
8. Biological Notes on the Pack Rat Cuterebrid. R. H. Beamer, U. of K.
9. The Beekeeping Situation for 1943. R. L. Parker, K.S.C.

Joint Session

Mathematical Association of America

Kansas Section

and

Kansas Association of Teachers of Mathematics

Morning Session

9:30 a.m. to 12:00 noon, Frank Strong Hall, Room 9

C. F. Lewis, K.S.C., presiding

1. A Correspondence Refresher Course for Mathematics Teachers. Mrs. Minnie Robertson, U. of K. 15 min.
2. Mathematics in War. R. W. Babcock, K.S.C. 30 min.
3. Mathematics in Air Navigation. Paul Eberhart, Washburn Municipal U. 15 min.
4. Cryptography—Secret Writing. G. W. Smith, U. of K. 60 min.
5. Business Session. Daniel B. Pease, presiding.

12:00 noon Luncheon—Memorial Union Building.

1:45 p.m. Business Session, Kansas M.A.A. Frank Strong Hall, Room 9, C. F. Lewis, Presiding.

Afternoon Session

2:00 p.m., Frank Strong Hall, Room 9

DANIEL B. PEASE, Wyandotte H.S., presiding

1. A, B and C—The Human Element in Mathematics. Angus Springer, Wyandotte H.S. 15 min.
2. Adjustments in Mathematics to the Impact of War. G. B. Price, U. of K. 15 min.

Physics

Chairman, W. D. BEMMELS

9:00 a.m. to 12:00 noon, Blake Hall, Room 210

1. Recent Developments in a New Type of Navigating Instrument. N. Wyman Storer, U. of K. Lantern. 10 min.
2. A Sky-projection Chart for Students of Astronomy. R. F. Miller, Baker U. 5 min.
3. Conversion of a Radio Receiver into a Code-practice Oscillator. W. D. Bemmels, Ottawa U. Lantern. 5 min.
4. Modern Physical Theory in the College Text. C. V. Kent, U. of K. 10 min.
5. Experimental Values of the Dielectric Constants of the Methanol-Water System from 5° C. to 55° C. Penrose S. Albright and Louis J. Gostling, Southwestern College. Lantern. 10 min.
6. Light-Gathering Power of the Extra-spectographic Optical System. Gordon L. Griffith and J. Howard McMillen, K.S.C., Lantern. 10 min.
7. Vibration Spectra of Normal Paraffin Hydrocarbons. Stuart E. Whitcomb, K.S.C. Lantern. 10 min.
8. The Vector Model of the Atom. C. V. Kent, U. of K. 10 min.

Psychology

Chairman, O. W. ALM

9:00 a.m. to 12:00 noon, Frank Strong Hall, Room 21

1. Hypnosis as an Experimental Technique. Margaret Brenman, The Menninger Clinic. 15 min.
2. Fascist Attitudes of Kansas State Teachers College Students. Clena Vee Ingram and Edward W. Geldreich, K.S.T.C., Emporia. Lantern. 15 min.
3. Relationship between Scholastic Achievement and Social Participation in College. E. L. Fiedler and J. C. Peterson, K.S.C. 10 min.
4. Effect of Temperature Changes on the Behavior of the White Rat. Kenneth Moore, U. of K. Lantern. 12 min.
5. The Form of the Curve of Retention for Substance Prose. Lester J. Briggs and Homer B. Reed, F.H.K.S.C. 12 min.
6. A Memory Study Employing a Factorial Experimental Design and the Analysis of Variance. Maurice C. Moggie, K.S.C. 15 min.
7. Mental Work Blocks and the Galvanic Skin Response. Edward W. Geldreich, K.S.T.C., Emporia. Lantern. 15 min.
8. The Development of Concept Formation in Children. Susanne Reichard, The Menninger Clinic. Lantern. 15 min.
9. The Effectiveness of the Divided-Recitation Supervised-Study Period in Kansas High Schools. Ernest C. Goforth and V. L. Strickland, K.S.C. 10 min.

10. Autokinetic Reactions of Psychotic Patients. Albert C. Voth, Topeka State Hospital. 15 min.
11. Present Status of Perfo-Score, Chemo-Score and Electro-Score Devices. J. C. Peterson. K.S.C. (By title)

Zoology

Chairman, JACOB UHRICH

9:00 a.m. to 12:00 noon, Snow Hall, Room 101

1. Recent Molluscan Fauna of Meade County. Alice E. Leonard, Lawrence. Lantern. 10 min.
2. The Mollusca of the Wakarusa River Valley. Dorothea S. Franzen and A. Byron Leonard, U. of K. Lantern. 10 min.
3. A Report of Freshwater Jellyfish in Kansas. A. Bryon Leonard, U. of K. Lantern. 5 min.
4. A Tapeworm of the King Cobra. S. L. Loewen, Tabor College, Hillsboro. Microprojector. 3 min.
5. A Historical Study of Skeletal Muscle and Connective Tissue in Vitamin C-Deficient Guinea Pigs. Mary T. Harman and Jessie Pelham Traulsen, K.S.C. Baloptican. 10 min.
6. Gonadotropic Effects of Capon and Normal Male Blood Serum. Bernice Christesen and E. H. Herrick, K.S.C. 6 min.
7. Stilbestrol as an Estrobenic Substance in Young Female Chickens. E. R. Herrick, K.S.C. Lantern. 8 min.
8. The Weight of the Lungs in the Fetal, Newborn and Adult Cat. Homer B. Latimer, U. of K. Lantern. 10 min.
9. A Case of Hernia in the Superior Duodenal Fossa. Homer B. Latimer and Charles Wolfson, U. of K. 6 min.
10. Histological Observations on the Anterior Pituitary (Hypophysis) of the White Rat. Henry W. Voth and Hazel E. Branch, U. of Wichita. Lantern. 10 min.
11. Presence of the Cotton Rat, *Sigmodon hispidus,* in Crawford County, Kansas. L. Gier, William Jewell Col., Liberty, Mo. Lantern. 3 min.
12. Handbook of the Common Insects of Kansas. Roger C. Smith, K.S.C. 5 min.
13. Alfredo Duges' Types of Mexican Reptiles and Amphibians. Hobart M. Smith and Walter L. Necker, U. of Rochester. (By title)
14. Comments on Jan's Papers on Venemous Serpents and the Coronellidae. Hobart M. Smith, U. of Rochester. (By title)
15. Notes on the Mansfield Museum's Mexican Reptiles collected by Wilkison. Robert M. Smith and M. B. Mittleman, U. of Rochester. (By title)
16. A Review of "Neotropical Lizards in the Collection of the National History Museum of Stanford University." Hobart M. Smith, U. of Rochester. (By title)
17. Movements in Early Forming Sperm in the Cockroach. W. J. Baumgartner, U. of K. (By title)

1
Presidential Address
The Effect of Climate on Human Behavior in History

RAYMOND HOLDER WHEELER, University of Kansas, Lawrence

In 1863 John W. Draper, an eminent American scientist and historian of his day, said that "Where there are many climates there will be many forms of men. . . . For every climate and, indeed, for every geographical locality there is an answering type of humanity." Herein, Draper thought, lay the explanation of the energy of human life and the development of civilizations.

Physicians, historians, philosophers, geographers, and statesmen in almost every century since the time of ancient Greece have recorded as their judgment that man is in profound and sundry ways affected by the climatic characteristics of his environment. These observers of the past have been in almost complete agreement regarding important correlations between man and climate. In cooler climates man is more vigorous, more aggressive, more persistent, stronger physically, larger, braver in battle, healthier, and less prone to sexual indulgence. In warm climates man is more timid, smaller, physically weaker and less courageous but more inclined to physical pleasures, more effeminate, lazier, and less aggressive. Peoples of cooler climates treasured liberty, were averse to slavery, built democratic societies. Warmer climates, it was noticed, were conducive to the more reflective pursuits; the birth rate was much higher in the colder regions even though there were more women, proportionately, in the warm countries, and the warmer races were considered to be emotionally less stable and dependable.

Jean Bodin, famous political writer of the 16th century, found that the northern races were more faithful to their governments but less fanatic in religion, and they were more tolerant, docile, and gayer, more trustworthy and less cunning, while the southern and warmer races were more melancholic, malicious, foxy, cruel, less democratic, and more given over to slaves, tyrants and dictators. Aristotle had commented on the willingness of people in the south to remain in subjection.

Scholars in the 17th century had relatively little to say about the effect of climate on human beings, but in the 18th century the subject was revived with a great deal of interest and vigor. Richard Mead, an English physician, in a publication of 1762, wrote a *Treatise Concerning the Influence of the Sun and Moon upon Human Bodies,* apparently taken largely from Bodin, but more scientific in attitude. He brought humidity into the picture as well as temperature. So did John Arbuthnot, in 1733, in his book, *An Essay Concerning the Effect of Air on Human Bodies.* He noticed that despotism was more frequent in the south and democracy farther advanced in the north. Said Arbuthnot, "Governments are powerless to change the genius and temper of a race against the force of air and climate."

We now come to Montesquieu, who included in his *Spirit of the Laws* the most extensive account of the problem to 1748. In warm climates people are

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weak, timid, apathetic, extremely sensitive to pleasure and pain, prone to sexual indulgence, given to the observance of immutable laws and religious mannerisms, stubbornness and tyranny. People in cool climates are stronger, braver, less suspicious, more puritanic in their behavior, are less interested in indulgent pleasures, more frank, and are the conquerors in war. Statute laws, Montesquieu insisted, should be made to fit the character and temperament of different peoples, thus climatically conditioned.

In 1743 Buffon, the naturalist, made several observations on climate and human behavior in which he was substantially in agreement with his predecessors and contemporaries. Adam Ferguson, 1768, evidently influenced by Montesquieu, included a chapter on the subject in his *History of Civil Society*. After making the usual comments he stressed a temperate climate as the best for mankind, for it produces superior traits. The answer, he suggested, is to be found in the effect of climate on human physiology.

After Ferguson's day interest in climate drops out of the picture again for a considerable time.

The historian, Henry Thomas Buckle, who died in 1862 at the age of 41, recognized in his work, *The History of Civilization in England,* the importance of food, soil and climate. Warm climates produce too much lassitude and are not fitted for labor, while cool climates make regularity of labor possible, hence contributing much to the economic advancement of the country. In regions that are too cold, the chain of industry is broken by winters that are too long and severe. Climate and geographical environment affects our habits of thought profoundly. Man is better off where the works of nature are small and feeble, requiring him to rely upon his own initiative and resources; thus an inquisitive and analytical spirit are engendered

The Berlin geographer, Karl Ritter, exerted an influence in the middle of the 19th century in favor of a geographical interpretation of history. One of his followers was the Leipzig geographer, Friedrich Ratzel. He, too, regarded the temperate zone as the best for human progress. It produced superior traits and similar political models.

In France, L. F. Moury, historian and archeologist at the College de France, offered little that was new but added the observation that peoples living in the mountains were noted for their tolerance of one another, their democratic ways, and passion for freedom. Of special interest to Americans, perhaps, is Arnold Henry Guyot, a Swiss geographer, who came to this country in 1848 and became professor of geography at Princeton. He wrote *Earth and Man, Comparative Physical Geography*. According to Guyot, traits of hot climate peoples are physical weakness, inaction, passion, sentiment, repose, a domination of imagination over intelligence and reason, and mysticism. The changes of the seasons in the temperate zone, he suggested, and the cooler temperatures, were responsible for more activity and movement, greater physical strength and intelligence, more forethought and persistence, and more provident habits. The temperate zone was thus superior both for physical and social evolution.

Coming now to the twentieth century, Ellen Semple, a student of Ratzel, makes the same distinction betwen northerners and southerners. Climatic conditions greatly influence the density of populations and the rate of reproduction, and further, "gives a certain zonal stamp to human temperament and development." In 1902 Robert DeCourcy Ward in *Climate, Considered*

Especially in Relation to Man is convinced that climate is one of the most important controlling factors in human development. He agrees with his long line of predecessors that the temperate zone with its seasonal changes is the best suited for human vitality, for the tropics offer too little stimulation while the heat drains man's energies, and severely cold climates absorb so much of his vitality that he has little left for anything else. J. Russell Smith wrote an *Industrial and Commercial Geography* in 1913. Cooler climates, he says, are a great stimulus to the activity of nations as well as of people. He points out that the greater cities of the world, New York, Boston, Philadelphia, Washington, Chicago, London, Liverpool, Edinburgh, Paris, Berlin, Hamburg, Leipzig, Vienna, Rome, Milan, Leningrad, Moscow, Peiping and Tokio, are all within 30 and 60 degrees north latitude. "To an extent little realized," he wrote, "environment makes the race."

There have been two twentieth century economists in this country, Henry L. Moore and Edgar Lawrence Smith, who have pointed out that economic and production cycles are, in the main, closely related to climatic fluctuations. Rainy years produce abundant crop yields which affect the economy of society, according to Moore. Smith thinks that there is an economic response to solar changes. "Within the economic pattern of a period," he writes, "the tidal ebb and flow of mass psychology in response to the rhythms of environmental change cannot be safely disregarded. . . . We need to know much more than we do about these natural rhythms and about the means by which they influence the moods of men; their hopes, their fears, their energies and their lassitudes." (*Tides in the Affairs of Men,* N. Y., Macmillan, 1939, p. 175)

Of necessity we have had to omit references to the work of many men. But there is Eduard Brückner, the Swiss geographer of the late 19th century, who reviewed the history of the recent climate of the earth up to 1890, noted a relationship between climate on the one hand and migrations and certain economic trends on the other. There is also the Russian investigator, A. L. Tchijewski, who has published voluminously and finds a relationship between wars and the sunspot cycle, a believer in the effect of ionization of the atmosphere on man's activities. And lastly there is Harlan True Stetson, astronomer, who has written a book on *Sunspots and Their Effects,* 1937, a review of the literature.

There are today in this country four major projects in the general field of human ecology, all of which have been running for many years. The oldest and best known of these four is the work of Ellsworth Huntington, geographer and climatologist at Yale University. The following titles suggest the scope of his investigations, which began very early in the century: *Geographic Environment and Japanese Character, Civilization and Climate, Physical Environment as a Factor in the Present Condition of Turkey, Maya Civilization and Climatic Changes, Climatic Variations and Economic Cycles, Palestine and Its Transformation, Climatic Change and Agricultural Exhaustion as Elements in the Fall of Rome, World Power and Evolution, What the Air Does to Us, Environment and Racial Character, The Pulse of Progress,* and lastly, *The Season of Birth.*

According to Huntington, climate profoundly influences the capacity to work, intelligence, and human behavior, even to the rise and fall of civilizations, not only through its control of crops and food supply, but directly as a stimulant

or depressant. There is an optimum temperature and storminess for human vitality, an optimum belt around the earth which includes the northern half of the United States and southern Canada, angles north to cross Great Britain and western Europe, and with certain complications, extends across south Russia and northern China. Storm tracks are significant, for storminess is in itself an important psychological and physiological stimulant. Changeableness in temperature, within an optimum temperature range, is conducive to human vitality and aggressiveness. It makes a difference, Huntington finds, what month of the year one is conceived in, in regions that have well-marked seasonal changes. In New England, for example, the late spring months are the best, producing February and March births. During spring the conception-rate curve puts in a peak in the northern hemisphere and the curve reverses in the southern hemisphere. The hot summer months produce declines in the conception rate. The life spans of people conceived in spring are longer than those of people conceived in late summer. There is, as a rule, a fall increase in the conception rate and a midwinter decline, indicating that sexual behavior, as one might expect, is a function of energy level.

Dr. C. A. Mills, another vigorous investigator, professor of experimental medicine at the University of Cincinnati Medical School, is the originator of the second of the four current projects in this country. He finds, with Huntington, seasonal variations in the conception rate. Dr. Mills has written *Medical Climatology* rich in experimental facts, and has just published a new book, *Climate Makes the Man.* Perhaps his most important contributions have come from his mice colonies, which for many years he has been studying under cool, medium and warm temperatures. The different colonies are physically and physiologically different, having different body types and rates of metabolism and different energy levels. He shows that energy level is a function of the ease of maintaining internal body temperature against excessive heat or cold outside.

The third project is also one in medical climatology, conducted by Dr. W. F. Petersen of the University of Illinois Medical School. His four-volume work on *The Patient and the Weather* is packed with statistics and curves showing the relationship between the incidence of different diseases (both mental and physical) and the weather. Different human personalities react differently to the same weather conditions. Some stabilize on a rising temperature curve, I suspect the introverts, others on a falling temperature curve, probably the extroverts. Recall how observers over the centuries have remarked upon the meditative, reflective character of warm region people. They are the introverts. Humidity, of course, is also an important factor in human behavior.

The fourth project, the one herein reported, is the youngest but perhaps the most ambitious as regards the effect of climate and climatic changes upon human behavior. It began over ten years ago, not as a problem in human ecology but as a study of fluctuations in human thought and attitude stumbled upon by accident and confined at first to fluctuations in points of view in the histories of psychology, biology, and philosophy.

It seemed hardly explainable that these three subjects fluctuated by chance together from one point of view to its opposite and back again down through history. The problem became even more fascinating when upon an examination of the other sciences it was found that they were varying in essentially

the same manner. "Fashions in science," as Schroedinger, the mathematical physicist, once put it, seemed to be strangely synchronized. This coincidence suggested looking still further into the history of human achievement, into art, literature, music, and even into political history. The same pattern was repeated in so many ways, in so many countries and cultures, in so amazingly a precise and objective manner, that the results seemed almost uncanny. Forthwith a rough curve was drawn of these see-saw movements, actions and reactions, characteristic of entire culture-patterns, north and south, east and west, covering every known country in the world upon which historical information could be obtained. Then another accident happened. A friend of the project, after listening to a discussion of this curve, suggested looking up A. E. Douglass' and Huntington's sequoia tree-ring curves for he thought he noted a resemblance between the culture curve and the tree curves. The author had never seen a tree-ring curve. But, upon examination, there it was. A definite resemblance of the one curve to the other was readily discernible. The peaks and valleys in the culture curve corresponded with the 50-year smoothed tree-growth curve in a fashion that chance could not possibly explain. The tree-ring curve suggested at once a possible climatic explanation for the culture fluctuations. The next step was to assemble all the information possible about the history of climate and to obtain some idea, if the data warranted it, of the alternating cold and warm, wet and dry periods of history.

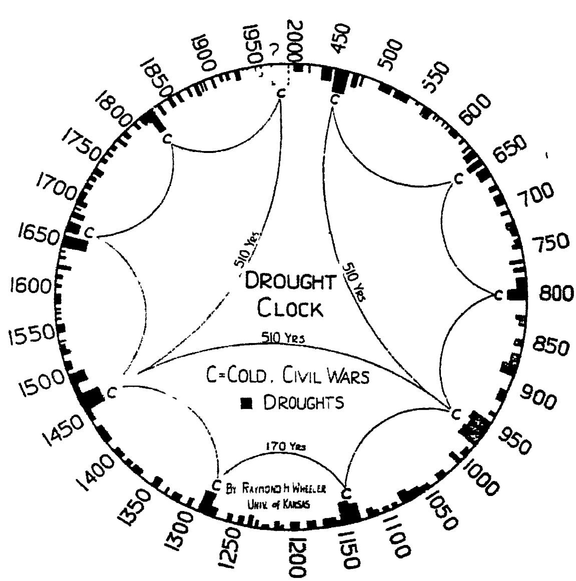
A proposed climate curve for the earth as a whole, back as far as measured temperature and rainfall go, was first worked out showing the warmer or colder, wetter or dryer periods, and periods of the different combinations of these variables: the warm-wet, warm-dry, cold-wet, and cold-dry. These combinations were found to follow one another more or less regularly in the order named and to repeat themselves in cycles of varying lengths. Tree growth, in general, registers these four sequences in a synthetic manner, putting in a maximum during the warm-wet climatic phase, a minimum during the subsequent hot drought (usually of lesser duration); a second recovery during the next revival of rainfall while it is turning cold, and another, usually longer and lower minimum during the cold-dry phase in which both variables, temperature and rainfall, operate against rapid growth.

The next step was to collect such available evidence as could be found from miscellaneous sources regarding the general condition of climate back to 600 B.C. Britton[1] has an excellent chronology of the weather in Great Britain from about the second century A.D. to 1450. Hosie[2] has brought together a chronology for China that is over 1500 years long. There are shorter chronologies for parts of Europe. All of Brückner's data, published in 1890[3] were used. These and other sources of information include reports of droughts, floods, general storms, thunder storms, excessive heat and cold, famines (generally from drought), epidemics (generally excessively dry or wet), lake levels, river levels, clay varves, harvest dates, early and late frosts, ice forming and ice breaking dates, travel through the Alpine passes (open or blocked in winter), the formation of bogs, pollen analysis of soils, data on the weather from diaries, expansion and contraction of arid regions, data from military

[1]C. E. Britton, *A Meteorological Chronology* to A.D. 1450. London, 1937.
[2]A. Hosie, "Sunspots and Sun-Shadows Observed in China B.C. 28–A.D. 1617. *Journ. N. hina Branch Roy. Asiatic Soc.*, vol. 12, 1877, 91-95.
[3]Eduard Brückner, "Klimaschwankungenseit 1700", *Geog. Abh.* vol. 4, no. 2, 1890, 324 pp.

posts, data from monastaries, governmental records, data from accounts of campaigns and battles that ran into extreme weather, locust plagues (generally warm and dry), and types of vines, plants and vegetables grown in a given region as the climate changed or modified. A surprisingly large number of individual items are available from historical military records. Tree ring data are available from many areas in the United States, several European countries, England, Canada and Alaska. Many of these tree ring curves go back several centuries either through the overlapping of several generations of trees or through the extremely old age of trees living today, as in the case of the California sequoias. By the time all of this information is pooled, some 20,000 items become available exclusive of tree rings. These items mass or cluster on the time scale in such a manner as to make distinguishable a great many of the phases of the climatic cycle throughout history: cold-dry, warm-wet, warm-dry and cold-wet, and tell much the same story in general as do the tree-rings. The two sets of data combined leave little doubt as to the climatic

CLOCK OF COLD DROUGHTS AND CIVIL WARS



CLOCK OF COLD DROUGHTS AND CIVIL WARS

FIGURE 1. The climate of the earth shifts from warmer to colder periods and back again, frequently in rhythms. History shows that nations are built on shifts from cold periods to warm, when the human energy level temporarily reaches a maximum. Nations crumble on the shift from warm to cold. International wars are mostly warm, civil wars cold. Each phase, warm and cold, begins wet and ends dry. Cold droughts and centers of civil war epochs generally coincide. A major cold drought and civil war period occurs about every 510 years; generally less severe ones every 170 years. There are also shorter rhythms. Seemingly, in 1943, we are near the beginning of a cold period since it has been generally warm for about 45 years. Totalitarianism is typical of late-half warm periods; democracy is revived during cold times.

trend in the world as a whole for most of the decades of history. That is, it is reasonably certain to which phase of the cycle a given decade belongs, and whether one decade or another was warmer, colder, wetter or dryer, than the preceding or following decades. It is evident that during several scattered decades in history climate was "mixed", that is, heterogeneous, and that these decades occur either during slow transitions from warm to cold maxima and back again, or as temporary "breaks" during either a relatively long warm or cold phase Certain modifications of the pattern (Fig. 2) are evident in different parts of the world such as lags and leads, a greater or lesser rainfall recovery at the end of a warm period, a greater or lesser rainfall during the cold phase, or a slower revival of temperature and rainfall during the transition from cold to warm. For example, it is evident that on the shift from warm to cold, a rainfall recovery is likely to be unusually strong in the southwest region of the U. S., and in large areas of China. In China, it would appear that the recovery from a cold period is more irregular and slower, that the shift from warm to cold lags behind many areas of the earth, and that this shift is usually where China's flood maximum occurs, with a generous sprinkling of warm years. There are many other complications such as shifts in storm tracks and the migrating north and south of the temperature belt in the northern hemisphere in which there occur average annual temperatures of between 50° and 55° F. There are long secular trends, especially in rainfall, such as the rapid decline in California since 1878, and a slow rise in the North Atlantic states, but when these secular trends are more closely examined shorter fluctuations from drier to wetter and back again reveal a general agreement.

It should be mentioned here that there is doubt in some quarters concerning the existence of a condition that could be called "world-climate" but if one is not too absolute in his definition, and allows for a certain percentage of disagreement that always occurs, the data collected in this project hardly leaves the matter in serious dispute. After all, why shouldn't there be a world climate, *relatively speaking*, especially as regards fluctuations in temperature, when one great regulator of world temperature is the heat from the sun? Generally, the world over, sunspot minima are warmer, maxima, colder.

Britton and Hosie include reports of sunspots and aurora in their long chronologies. The sunspots, of course, were those large enough to see with the naked eye. These records have proved invaluable in checking the onset and duration of cold periods. Usually within five years after clusters of large sunspots have been reported other evidence unmistakably proves that a cold phase has begun Large sunspots are conspicuous for their absence during long warm periods and bunch during cold periods, especially at their onset. Furthermore, from the continuous telescopic sunspot record that was commenced in 1755 it is evident that the single sunspot cycle of 11.3 years suddenly lengthens at the onset of a warm period, shortens at the onset of the cold phase. The cycle averages longer during warm than during cold times.

It is unfortunate that time does not permit showing you graphs and charts of all this evidence, but you will have to wait for a lengthy, and I am afraid very monotonous publication. (See Fig. 2.) However, suffice it to say that we have converted this evidence into world maps in four colors, some 231 of them, and all you have to do to see these climatic fluctuations of history is to

EXPLANATION OF FIGURE

FIGURE 2. The upper part of Figure 2 shows schematically the successive phases of a short climatic fluctuation These phases are discernable whatever the length of the cycle. While the rainfall maximum generally occurs on the rising temperature curve, it occasionally occurs on the drop in temperature at the end of the warm period. There is some evidence that in certain regions of the earth the rainfall recovery at this time is generally the stronger of the two. In any case, it seems to be general that the rainfall maxima occur during climatic shifts from cold to warm or warm to cold. If the greater of the two rainfall maxima happens to occur on the drop in temperature, there seems likely a generous sprinkling of warm years at the time. Usually on the shift from cold to warm, temperatures recover ahead of rainfall so that there may be a short hot drought at this time. A few of these droughts have stood out conspicuously in history and one of them occurred during the rise of Napoleon. It seems probable that China frequently suffers droughts at this time. The pattern as just described is discernable in fluctuations as short as 7 years, but generally does not exceed the length of a single sun spot period.

If the warm and cold phases stretch the climatic cycle beyond the single sun spot period or at least beyond the double sun spot period, "breaks" to the cold side occur as shown in the middle of Figure 2 Here it may remain fairly wet. In general the tendency for rainfall and temperature to follow one another predominates over the tendency for these two variables to depart from one another. The hot drought phase is a conspicuous exception. The cold wet phase occurs at a time when the long time trend is a decline both in temperature and rainfall. If the warm period is long enough, several "breaks" may occur, each subsequent rainfall recovery becoming weaker until the hot drought phase is reached. When the cold period is a long one, corresponding "breaks" occur, but generally do not last beyond the length of the single sun spot period, frequently less. In a very long cycle, like the 510-year period, warm phases occur more frequently and are inclined to last longer during the warm half of the period, and cold phases occur more often and last longer during the cold half.

In the lower half of Figure 2 is represented the general picture of measured world temperature from 1870 to 1930. The departures consist of the percentage of warm stations for any given year in excess of the cold, or vice-versa. Thus, if the upper column reaches 30% it means that 65% of the available known weather stations of the world average above their long time means that year and 35% were cold. Notice that temperatures tend to become more uniform during the warm than during the cold periods. Note that 1870 to 1895 was a cold phase and 1895 to 1930 a warm phase. The 1930's were evidently very warm. The total number of stations involved varied from 85 in the 1870's to 270 in the 1920's. By five year periods the excess warm over cold may run as high as 50% or over during the hot drought phase, which means that 75% or more of the stations are above their long time average and only 25% below. It is believed that the per cent excess of warm over cold stations reached a still higher figure in the 1930's. During the cold phase, by 5 year periods, the cold stations may exceed the warm by as much as 35 to 40%.

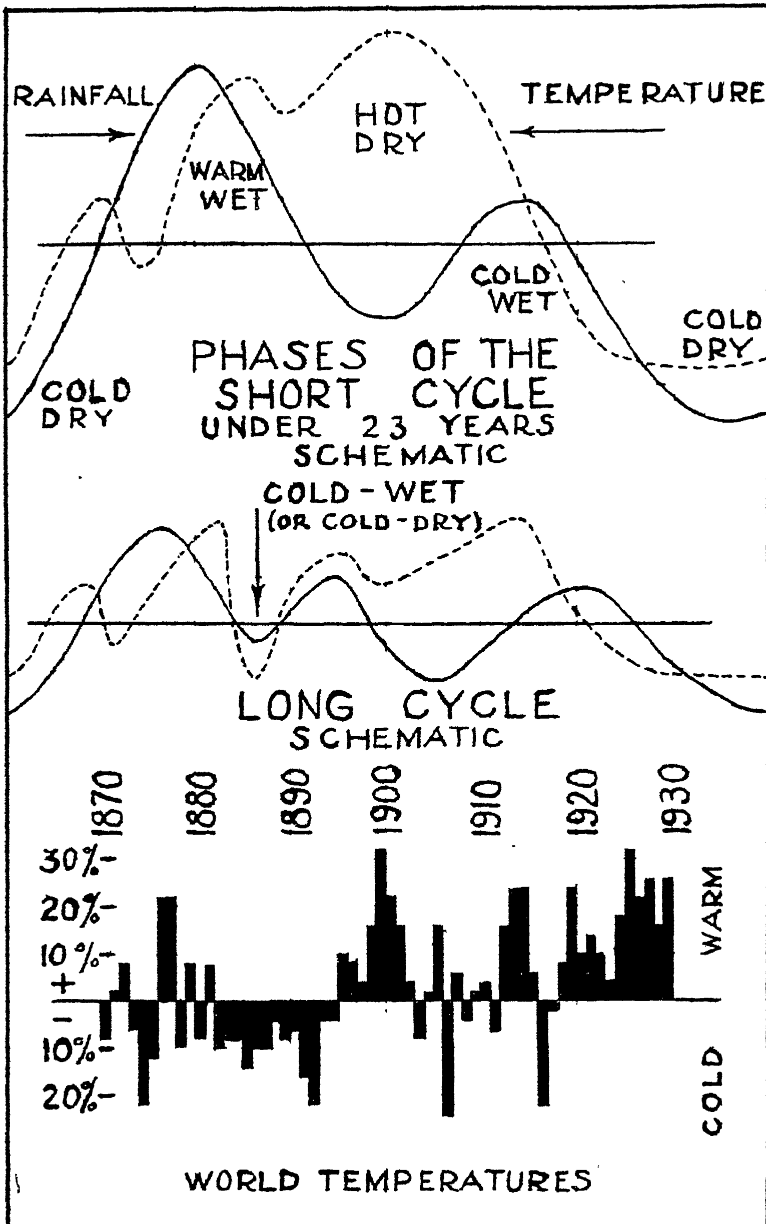

RAINFALL
TEMPERATURE
HOT
DRY
WARM
WET
COLD
WET
COLD
DRY
COLD
DRY
PHASES OF THE
SHORT CYCLE
UNDER 23 YEARS
SCHEMATIC
COLD - WET
(OR COLD - DRY)
LONG CYCLE
SCHEMATIC
1870
1880
1890
1900
1910
1920
1930
30%
20%
10%
+
−
10%
20%
WARM
COLD
WORLD TEMPERATURES

FIG. 2

turn the pages and see the colors change. These maps run by periods averaging about 25 years in length from 600 B.C. to 1200, then by decades to 1680, then by half-decades to 1930. In addition, we have annual maps from 1870 to 1930. These maps include measured temperature and rainfall as obtained from Clayton's[4] two volumes of tables published by the Smithsonian Institution, and from several other but minor sources, as far back as these records go.

This project recognizes and has taken into account in its conclusions the many objections that have been raised, both toward a study of this kind and toward conclusions regarding "world climate". Some of the objections are: variations in the behavior of trees in the same region, perhaps only a few miles apart due to differences in soil and water run-off, or to "accidents" in the distribution of rainfall; local exceptions to general trends in rainfall and temperature, especially in rainfall; the fact that in different regions seasonal rainfall varies, as for example a heavy winter rainfall in one region and light in another; the shifting of storm tracks; the geography of the different regions of the earth; latitude differences; diverging, long-time secular trends, and many others. But all of these well-known conditions fail to obliterate the empirical fact of general world trends in climatic fluctuations. Numerous coefficients of correlation were worked out. These have been published.[5] For the world as a whole (300-400 weather stations distributed as evenly and widely as possible over the five continents) warm stations exceed the cold (during the warmest decade) and cold stations exceed the warm (during the coldest decade) by 30 to 50%, according to the location. The average excess is around 40%, i.e., 70% of the stations are warm or cold, 30% the opposite.

The difference between the average temperature on the warm side and the average temperature on the cold side, in the case of measured temperature in the middle temperate zone, is surprisingly small. It is in the neighborhood of a degree and a half F. But at this latitude the difference between the average temperature during the hot-drought phase and the average temperature during the cold-drought phase is twice that much, about 3 degrees. To the objection that differences as small as these could not affect behavior, there are many answers. A difference of 3 degrees F. in mean annual temperature is the equivalent of moving the latitude of a given region some hundreds of miles north or south, and has vast correlates when observed in relation to the absence or presence of extreme weather, such as the length and severity of the winter, the coolness of the summer, early and late frosts and the like. The difference between hottest and coldest decades in the cycle shrinks to about one degree in the tropical zone, but still exists there, and rises to 5 degrees in the northern latitudes as in Canada and Siberia. Another answer is the known delicacy with which life in general is adjusted to average temperatures and rainfall. Take, for example, wheat in western Kansas where there is on the average 12 inches of rain per year. That 12 inches is a minimum. Should the rainfall drop an inch the effect on successful wheat crops over a period of years would be proportionately greater than the relative drop in rainfall might suggest because the chances would be so much less of sufficient rain or rain at the right time. Still another answer is the known effect of temperature on

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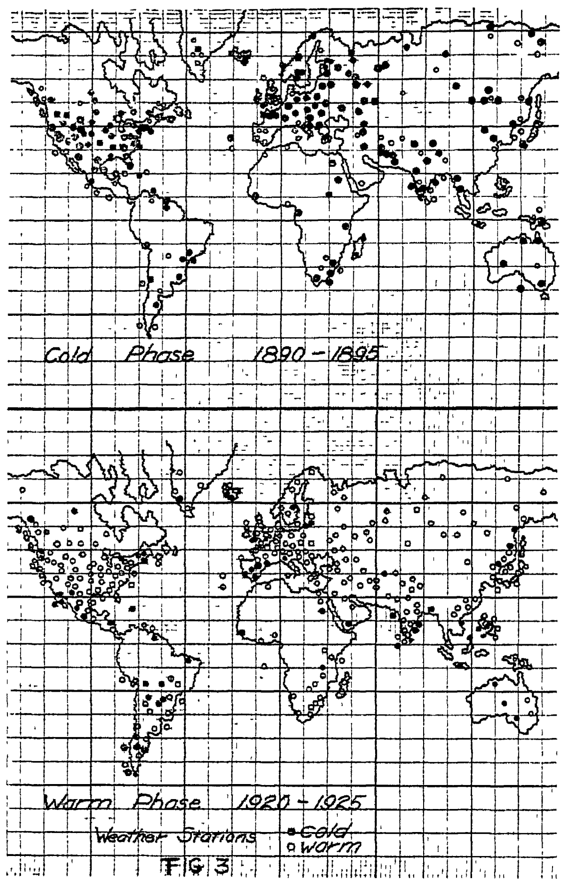
[4]H. H. Clayton, *World Weather Records,* Smith. Misc. Coll., 1927, 1932.

[5]Raymond H. Wheeler, "The Problem of World Climate", *Bull. Amer. Meteorol. Soc.,* vol. 21, 1940, 46-58.

animal behavior, with experimental animals raised in artificial climates. While differences in temperature as small as three degrees have not been used, rats living at a constant temperature of 85 show many deficiencies in behavior as compared with rats living at room temperature which averages 85 degrees

FIGURE 3. The upper half of Figure 3 shows the distribution of available weather stations that average cold in the decade 1890-1895. It was at that time that the cold period, extending generally from 1830 to 1895 or '97, reached one of its climaxes. Approximately two-thirds of the stations were cold, and one-third warm. The cold exceeded the warm by 33%. Note that the warm stations are pretty well scattered, although certain areas were apparently warm, such as Greenland, northeastern North America, a part of Mexico, parts of South America, Spain and the Western Mediterranean region, New Zealand, part of Siberia, and Japan The lower half shows the distribution of weather stations that averaged cold or warm in the half-decade 1920-1925, in which the warm were in excess of the cold by nearly 50%. Note that the areas that showed cold trends during this period were for the most part areas that were warm in the early 1890's.



It is quite possible that this represents a general fact—namely, that certain areas of the earth run opposite to the general trend more or less consistently.

These two maps show what is meant by the phrase, "world climate," and indicate roughly the extent to which the land masses of the earth are warm during warm periods and cold during cold periods. At no time, probably, are all of the stations warm, or all cold. Miscellaneous data and measured data prior to 1870 indicate that the picture during the coldest part of the cold period generally approximates that of the early 90's. On the other hand, there are reasons for believing that the homogeneity of warmth during warm maxima is greater than in the early 1920's. If prevailing temperatures relative to the long-time means have exhibited the contrast all down through history during cold and warm maxima that is shown in this figure, it can easily be understood why the accompanying culture changes have been so widespread.

during the summer months and 75 degrees during the winter. Moreover, temperature differences of 25 degrees produce *enormous* differences in behavior in the white rat, as demonstrated in our own laboratory. Our "cold" rats, living at 55° F., are four times as smart as the "hot" rats living at 90° F., as measured by maze-learning. And finally, it is not assumed that temperature is the only condition that affects human behavior. It so happens that the mean annual temperature range in which human beings have developed intelligence and civilization prevails in the climatic cycle during transitions from warm to cold and cold to warm. These are also the times when it is raining the most, *i.e.*, when it is also the most stormy. It is also the time when temperatures are the most variable day by day and year by year. Thus there are obviously modes of stimulation or energization other than the degree of absolute temperature prevailing at a given time. Huntington thinks that ozone, associated with storminess, is an important factor. It may very well be. In any event, it is evident that not one but several integrated factors contribute to the changes in human behavior that are correlated with climatic fluctuations.

Whatever the ultimate explanation will be, the empirical fact regarding differences in human behavior during warm and cold times and during climatic transitions are clean cut. I wish I had time to go through the detailed evidence with you. Concluding from animal studies, these behavior changes are probably due to changes in energy level. The quality and amount of human behavior during warm and cold times, respectively, point to this conclusion. Further, why should the major economic depressions of history be associated with excessive temperatures and drought, and booms with rainfall revivals? Why did the human birth rate and the animal birth rate decline during the excessively warm 1920's and 1930's, especially the 1930's? You will remember that the dictator nations tried their best to get the human birth rate back to normal again, but unsuccessfully, according to the testimony of their own physicians. Why should all the known declines in human birth rate in history have been associated not with wars but with hot droughts? Why is it that conception declines with increase in temperature above a certain limit? The age of maturing in girls in the southern part of the United States is on the average one year behind the corresponding age in the northern part. Why should the great revivals of learning, of good government, of genius, of economic and political aggressiveness, long rises in production, and the numerous other events of "Golden Ages" all come at the same time on the cycle along with increases in the birth rate in man and presumably in animals? Why when decadence occurs, is it general, and always associated with extreme temperatures? Why is stability of behavior associated with "optimum" temperatures and instability with excessive temperatures? I believe that fluctuations in human energy level is the only answer, and the correlation between behavior fluctuations and climatic fluctuations down through history is empirically general and constant. We can find nothing that looks like a genuine exception. But I am getting ahead of my story.

Assuming that the information on the history of climate, just discussed in so general a fashion, is reasonably accurate, the observers of ancient times knew in the main what they were talking about. *The patterns of human behavior almost universally described as distinguishing the northerner from the southerner distinguish the behavior of peoples in all the temperate lati-*

tudes during the cold phase of a climatic fluctuation from their behavior during the warm phase. That is, northerners take on the psychological characteristics of their more southern neighbors during warm times, and southerners become more like their northern cousins during cold times. During cold times the qualities of the northerner become more "northernish," while during warm times those of the warmer climates become more "southernish".

Aristotle, Vitruvius, Thomas Aquinas, Bodin, and Montesquieu, down to present day observers, stressed the more meditative, reflective, mystical pattern of the warm-climate mind. This behavior is true today of the warmer, Oriental peoples. Moreover, waves of interest in Oriental culture and thought sweep the Occidental countries during warm times. In the Occident, the great deductive and reflective philosophies of the rationalists and idealists have, without exception, cropped out during the warm phase of a climatic cycle from the time of Plato and Aristotle down through Plotinus in the 3rd century A.D., through Thomas Aquinas of the Middle Ages, through Spinoza and Leibnitz of the 17th century, Hegel, Fichte and Schopenhauer of the early 19th, to the 20th century modernists in idealism and rationalism. Contrariwise, the simpler philosophies that were less patient with thinking processes and were skeptical, shallow, and materialistic, have occurred during cold periods ever since the first known skeptics of Ancient Greece.

Various writers have noticed the melancholy, fatalistic attitude of the southern, or the warm-climate mind. The great literatures of the European nations, beginning with ancient Greece, based on fate and tragedy, have emerged and flourished during warm periods all the way from the ancient Greek dramatists down through Shakespeare to Eugene O'Neill. Contrariwise, literatures emphasizing gayety, fun, comedy and freedom have emerged during cold periods, from the Greek romantic lyricists and comedians down to Dickens and Mark Twain.

Recall that observers throughout history have agreed on the so-called indulgent, passionate and "sexy" behavior of warm-climate man as compared with the inhabitants of cooler climates, and yet the birthrate is lower in warm climates World maps show indisputably that with minor exceptions the world as a whole has passed through a temperature climax during the last few decades, and that we have averaged on the warm side of the line since about 1897, with the usual temporary breaks to the cold side. It is officially recognized that during this temperature climax, when it was getting drier all the time, the birth rate markedly declined over much of the world. Germany and Italy, as we have said, were alarmed and did everything in their power to produce more little Nazis and Fascists. In this country there were only four regions during the 1920's and 1930's where the birth rate did not decline sharply. These regions were in the mountains, where it is cooler. Associated with this decline in the birth rate there has developed a hyper-sex-consciousness which has expressed itself in various ways: in an increase in immodest behavior, in public necking, in a decline in the distinction between girls who are respectable and those who are not, and in nudism. As a result we have more sexual behavior and a lower birth rate. Once more the warm phase of a climatic cycle in the temperate zone leads to the warm-climate modes of behavior that are found more constantly in latitudes nearer the equator. The same excesses have occurred many times in history under similar climatic conditions.

Recall how observers down through history agreed that warm-climate peoples were more prone to fanaticism, cruelty, tyranny and dictators. These phenomena have concentrated, all down through history, from the days of the Greek Tyrants to Hitler, Mussolini and Stalin, during the warm phase of the climatic cycle. It is during these times, especially when they are dry and therefore hotter yet, that minorities suffer their worst persecutions, liberties are curtailed, and fascism and communism develop. Hitler is a typical hot-drought specimen! Socialistic trends—any form of shift from individualism toward greater state control and ownership—are warm-phase phenomena and, when extreme, are symptoms of decadence.

It turned warm in the middle of the 5th century B.C., during the days of Pisistratus of Greece, Periander the Tryant of Corinth, and the tyrannical oligarchy of Samos. The longer it remained warm the more fascistic the tyrants became. Early in the warm period, near the shift from the cold side, these tyrants were more liberal and democratic. Around 570, it is said, lived Tarquinus the cruel tyrant of Rome, who was later murdered. This was also the period of Cambyses, the decadent, ruthless and destructive tyrant of Persia.

Recall that observers down through history have agreed upon the more democratic nature of peoples living in cooler climates, and remarked upon their aversion to slavery and their passion for freedom. Democratic institutions have always emerged and have grown during cold phases, even in the temperate zone. By 520 B.C., following the tyrannies of the middle 6th century B.C., democratic reforms were on the way, over the known civilized world. Then came Darius in Persia; Rome turned republican; there were the reforms of Clisthenes in Greece. The Ionian cities revolted against Persia, as did the Scythians farther north. There were social or civil wars in Rome in which the Plebians won important concessions. Civil wars cling to the cold side of the cycle throughout history, along with democratic reforms such as the Magna Charta, model parliaments, franchise reforms and Reformations.

As a result of these cold periods, which are emancipatory in character, a new leadership forms and a good government revives. Then, as temperatures become average again and as rainfall revives there is a Golden Age. This change occurs on the transition from cold to warm and lasts into the warm period. Such a climatic event as this occurred around 490 B.C., when a score or more of strong states or empires sprang up, about which we have quite definite information. Around 415, and much of the time between 390 and 350, it was very warm again and dry, and along came another crop of tyrants. There were Archelous of Macedonia, Dionysius of Syracuse, dictators in Rome, massacres in Argos.

Time permits mentioning only the most famous of these dictator times down through history, all associated with hot drought conditions. No impressive dictator period has ever developed except during warm and usually dry times. There was, for example, Domitian in the 80's A.D., the Roman Emperor who called himself God and persecuted the Jews and the Christians, the Rome of Decius and Valerian around 250 A.D., when further persecutions of the Christians occurred, and again the Rome of the 260's at the time of Gallianus and the Thirty Tyrants, then, the reactionary Emperor Aurelian, who also called himself God. The same thing happened around 300 at the time of Diocletian. All these periods were warm and dry, according to the evidence. It

was warm and dry again in the 480's and 490's, during which the Vandals turned upon the Catholics and the famous communism of Mazdak developed in Persia.

During the early part of the 7th century hot and dry conditions prevailed, when ruled Heraclius the reactionary and fascistic Byzantine, and Dagobert, who set up a tyranny in France. This was the period, you will remember, of the famous Brunhilda, the traditional Frankish heroine who was dragged to death by being tied to wild horses. At the same time the Greek Empire resolved to exterminate the Jewish religion from the land. Anti-Semitism flared up all over Europe. The Persians sacked Jerusalem and the Persian king led his troops again and again to the slaughter in decadent warfare, even as Hitler sacrificed them at Stalingrad. Around 800, rulers everywhere, who began their careers in a constructive and liberal manner, now became fascistic and despotic as it turned warmer and drier. There were Irene the Cruel in Byzantium, the fanaticism and massacres of Charlemagne, the persecution of the image worshippers by Leo "The Chameleon" of Byzantium, and Louis the Pious, a French reactionary. Even the famous Haroun-al-Rashid in Arabia turned Hitlerian In the early part of the 11th century conditions of this sort became remarkably extreme. It was then so warm that trees grew in Greenland, and Iceland and Greenland could be colonized. The Hitlers of that day make an impressive list: among some 30 of them were Basilius II of Byzantium, Sviatopolk of Russia, Olaf of Norway, Cnute the Mighty of Denmark who set up a very despotic empire in Denmark and England, and Conrad II of the Holy Roman Empire. Basil II of Constantinople, victorious over the Bulgarians, deprived 15,000 captives of their sight. Mahmud of the Ghazni Empire in India burned thousands upon thousands of his captives at the stake. The Sultan of Turkey was at the same time showing a terrific passion for blood. The Jews were persecuted and banished from many countries. China became a militarized socialistic State.

The Inquisitions during the 13th century broke out during warm-dry conditions, and again when the Franciscans threw Roger Bacon into jail, and again at the time of the Sicilian Vespers, when also there was a general persecution of the Jews in Europe. Tamerlane in the late 14th century was a typical extreme hot phase character, even for an Asiatic.

Conditions repeated themselves in the 1520's and 1530's when there was another impressive list of tyrants and Hitlers the world over. Witness Henry VIII and the Acts of Supremacy, Francis I of France who restricted the rights of the Parlement, Montezuma II of Mexico who was a fanatic reactionary, and the Ottoman oppression in the Balkans. All over Europe there was a stiffening of resistance to the Reformation and the great Spanish Emperor, Charles V, allowed many fascistic practices to occur. Prisoners of war were treated as slaves in many lands. The Turks, in the Balkans, paraded with 2100 Christian heads on their pikes, and thousands of Christians were murdered in cold blood. Jews were persecuted again. The situation became worse shortly afterward, both in hot droughts and in tyranny. This was in the 1550's, during the time of Mary Tudor and the persecution of the Protestants. The Mogul rulers of India were exceptionally vicious and tyrants sprang up in the Italian cities. Philip II of Spain was noted for his frightful

persecutions both of the Moors and of the Protestants. Remember the poor Netherlanders?

There was hardly a known parliament worth the name anywhere in the world during the hot-dry decade of the 1630's. Kings called themselves gods even as in the days of the Romans and of Alexander the Great. Charles I was not the only despot. Over in Turkey there was Murad IV, called the Turkish Nero. Vladislav IV in Poland was a tyrant, and Louis XIII and Richelieu were not noted for their liberality. In Japan extreme reactionism set in Christians were at first forced to work in mines as convict labor and were finally run out of the country or massacred. In the year 1638 the Japanese massacred thousands of Christians, and in the same year infidels were slaughtered in Baghdad. Governor Winthrop, you remember, became a despotic ruler at this same time. Cromwell became a dictator during the warm-dry 1650's; France persecuted the Jansenites, and there was anti-Semitism even in the American colonies. The Jews suffered terribly in many European countries. The Mogul emperor in India at this time was a fierce, oppressive tyrant, and my eighth great-grandfather, Christopher Holder, along with many other New England Quakers, was persecuted by the Puritans. He was whipped again and again and had one ear cut off with a sword.

The late 17th century was very warm and relatively dry, save for a brief period in the 1680's, and as you all remember, extremely fascistic, even brutal, as this last hot-drought epoch had been. The Irish were severely repressed by the British; in England the Habeas Corpus act was suspended; in all non-European countries there were anti-Christian movements; the Jesuits began persecuting the Jansenites; there were furious massacres of the Montenegrans by the Turks; certain of the American colonies adopted Indian slavery; India's ruler, Alamgir I, was a cruel religious fanatic and bigot, a Mohammedan who tore down the Hindu sanctuaries by the hundreds, killed their priests and confiscated the temple treasures. Eventually his own sons rebelled against his atrocities. While all this was going on the armies of Louis XIV were ravaging the Palatinate; coffins were dug up and looted; homes and crops went up in flames; French subjects were forbidden to leave the country under penalty of losing all their possessions; agents were hired to kidnap Protestant children; the Protestants could not sing songs on land or water; they had to hold their funerals at night and were required to house the soldiers of the King. Thousands were tortured and killed. Does that not sound like Hitler?

After each one of these fascistic periods it has always turned cold, and rebellions and civil wars have broken out, resulting in reforms. These rebellions do not occur until the temperature begins to drop. So long as it remains warm, people will not vigorously resist. Sampling only some of these civil war, cold epochs, in more recent times, (see Fig. 1) there was the 15th century, an unusually cold period with its Hussite Wars, humanistic movements, Wars of the Roses, rebellions in the Holy Roman Empire, and civil wars all over the Orient. There was the time of Cromwell which was cold, save for the brief period in the 1650's already mentioned, with its Wars of the Fronde in France, civil wars in Turkey, in the Sudan, Deccan, India, the Philippines, Poland, Russia, Hungary, Spain, Portugal, Naples, Scotland and the Crimea.

Another great cold and civil war epoch occurred in the second half of the 18th century when we staged our little revolt against the British Empire. But

at the same time Catherine the Great had to put up with civil wars, as did Charles II of Spain. There was anarchy and chaos in Japan; the Crimea revolted against Russia. There were civil wars in Burma, Siam, Sumatra, Tahiti, Hawaii, Abyssinia, Samoa, Annam, India, Turkey, South Africa, Belgium, Formosa, China, and last but not least, France.

The rebellions of 1830 and of 1848 occurred at the beginning and end, respectively, of a cold period; our civil war, and others, as in Poland, Japan and Italy, occurred during the cold 1860's.

The years 1906 to 1912, marked by great civil wars in China and the Balkans, were cool, as were the years 1918 to 1922. It was a drop in temperature in 1917 and 1918 that seemingly had much to do with the rebellions that terminated World War I. These rebellions were at first democratic in Russia, Germany and Italy, but it did not stay cool. It turned very warm, and, as rebellions and reform movements have done all through history, when it turned warm too soon, absolutism, communism, fascism—some form of tyranny—got the upper hand and kept it.

Once more, in the 1920's and 1930's, history has repeated itself. The temperate zone turned away from democratic individualistic institutions, became decadent, fascistic, communistic, socialistic, hot and dry. Once more minorities have been persecuted. Once more civilization in the temperate zone revealed the pattern that observers all down through history saw prevailing in southern countries.

We mentioned that the transition from cold to warm marks a general Golden Age period in history. These ages are characterized by good government, a revival of genius and learning, art, literature and science, all expressions of a high energy level Of 53 rulers coming down through history with the title, "The Great," 49 or 91.7% have ruled in this phase of the climatic cycle. The reigns of only two have centered in warm-dry times, three in cold-dry times. Of 306 rulers whom historians characterize as good, but have not been given the title the Great, 67% were Golden Age rulers, *i.e.*, transition and early warm; 11% were warm-dry and 22% cold. Of 342 poor rulers of history, only 4% have come during transition and early warm times. Forty per cent were hot-drought characters, and 56% cold. The poor rulers of cold times were active enough, but not in the appropriate manner. They have been weak indulgers and profligates like Nero and Louis XV. Of 165 warm-dry rulers only 20% were good: 80% were bad, according to the verdict of historians. Of the 231 early warm Golden Age rulers, 92% have been pronounced good by historians. Of the 252 cold rulers of history 24% were good and 76% bad.

Golden Age periods are marked by great outbursts of human energy, and, we have reason to believe, high birth rates. The moral tone of society is high. These are the puritanic periods. But, also, these are times of great *nation-building* and imperialistic wars, which do not generally get under way until the warm phase of the cycle has begun. Early warm times, then, yield a crop of international or World Wars that we shall call Type One. Some of the great historic wars of this type are the Graeco-Persian, Punic Wars I and II, the conquests of Julius Caesar, the first conquests of Charlemagne, the opening of the 100 Years War and certain phases thereafter, the opening of the Thirty Years War, the opening of the Silecian Wars, the opening of the Napoleonic

Wars, the Crimean and Franco-Prussian Wars, the Spanish-American War, and World War I. Then, as it continues warm and as societies exhaust themselves in fighting, wars generally cease until the hot-drought phase is over, which ends the warm period. Then fighting starts up again on the transition from warm to cold, but now it is of a different character. Societies have become decadent; dictator nations have formed and these begin another

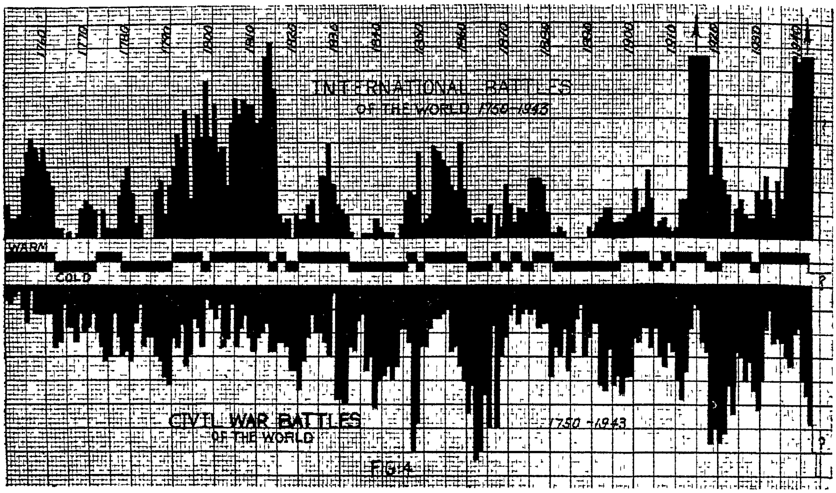


FIGURE 4. Figure 4 shows the distribution of international and civil war battles occurring in all known parts of the world from 1750 to 1943. The amplitude of the columns is a summation for a given year, when a mild engagement originally equalled 1/20 of an inch, a moderately severe engagement 2/20, and a very exceptionally heavy engagement 3/20. The international battles are in the upper half, the civil war battles in the lower half of the figure. Warm and cold years are indicated in the middle of the figure. Notice the prevalence of international over civil war battles in the warm 1750's, the small amount of international fighting during the cold period that extended from 1762 to 1790, and the increase in civil wars. Next, note the prevalence of international wars during the warm period from 1790 to 1813 and the decline of civil wars during the middle of this period Next, notice the sharp drop in international fighting during the cold "break" from 1813 to 1820 and the sharp increase in civil wars, and the reversal that occurred again in the warm 1820's. During the cold 1830's and '40's, there was practically no international fighting, but a great increase in civil wars. As it started to turn warm after 1845, note the rise of international wars that reached a climax during the warm 1850's. Further, note the decline of international wars and great outburst of civil wars in the cold 1860's. Another climax in international wars occurs in the late 1870's that were warm. The 1880's and '90's then repeat the 1830's and '40's. Note that with every drop in temperature after the last major warm period started, about 1897, there was an outburst of civil wars, and that again the international fighting predominates on the warm side.

During the earlier centuries of history, when warm and cold phases lasted longer, the contrast is much sharper than in recent decades. The international and civil war battles of world history have been plotted against climate beginning 600 B.C.

If we are now in a transition from a warm to a cold period, the international battles should drop off soon and civil war battles should increase, roughly as indicated at the extreme right of the figure.

wave of imperialistic wars, this time of a very degenerate character, which we can call *nation-falling* wars, wars of Type Two. Nations fall on the transition from warm to cold, as they rise on the transition from cold to warm. These wars have always been decadent affairs, as compared with the nation-building type, ever since the time of Alexander the Great, and have been fought with the aid of fifth columnists. Other wars of this type have been the Third Punic War, the Jagurthan War, when every Roman had his price, the looting of Egypt by the Romans in 25 B.C., the conquests of Attila, the Arabian conquests of Africa and Persia, the Arabian entry into Spain, the First Crusade, the Turkish invasion of the Balkans in the 13th century when 25% of the population were fifth columnists, the conquests of Kublai Kahn and of Tamerlane, the Turkish conquest of Constantinople, the Franco-Spanish Wars in Italy in the 1530's, when cathedrals were used as stables and fires kindled on the floor of the Vatican, the Turkish invasion of the Balkans in the 16th century when again many of the population were fifth columnists, the Joan of Arc phase of the 100 Years War when many of the French nobles sold out to the British, the Wallenstein-Thilly phase of the 30 Years War when Germany was pillaged, the final phase of the Napoleonic Wars, the Russo-Japanese War, and this, the so-called second World War. If these wars be compared as a group with the others, the differences are at once apparent. It is in the second group that the great massacres, pillaging, torturing, fanaticism, fifth column work, disregard for civilian rights, unsportsmanlike behavior and the like occur. The present war is running true to form, for it is evidently a *nation-falling* war. We have just had the hot drought. It is turning cold, or just has turned cold, and before long we should be entering a great civil war epoch. This means a revival of democracy.

The observers of the past had not noticed the relationship of wars to climatic fluctuations, but they made many observations now being borne out and refined in current investigations. Can one not, then, agree with Polybius, who said in 150 B.C., "We mortals have an irresistible tendency to yield to climatic influences; to this cause may be traced the great distinctions which prevail among us in character, physical formation and complexion, as well as in most of our habits."?

2

Microbiological Studies of the Effect of Straw Used as a Mulch[1]

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Converting the land of the virgin forest and prairie to the production of cultivated crops has permitted the ravages of soil erosion by wind and water to deplete the fertility of many American soils (2).

Recently, it has been found possible to lessen the soil deteriorating action of water and wind by leaving crop residues at the surface of the soil with a system of subsurface tillage (3, 4), rather than plowing under the residues or burning them. Duley and Russel (3) have shown that crop residues left on the surface of the soil reduce runoff and erosion to a high degree. It is possible by using a stubble mulch on the surface to protect land effectively against erosion while growing cultivated crops.

The practice of leaving residues on the surface of the soil and cultivating underneath them is radically different from the conventional method of handling land in cultivated crops. However, it is not so different from the method employed by nature in returning residues from grasses or trees to the surface of the soil where the residues act as a protective mantle. Microorganisms in the soil bring about the decay of plant remains, produce humus, and convert the mineral elements of the organic matter to a soluble form.

In order to know how the presence of a mulch affects the environment of the organisms, and hence their activities, the following points have been investigated: (A) moisture and temperature conditions, (B) soil populations, (C) amount and nature of mulch as influenced by decomposition, (D) decomposition products of soil microorganisms as they influence soil structure and water infiltration, and (E) production of soluble nitrogen.

It seems desirable to consider the influence of straw mulch on the soil as a medium for biological activity in order to plan wisely a cropping sequence which will provide a mulching material, secure maximum soil protection, maintain or increase crop yields, and provide for maintenance of soil fertility.

EXPERIMENTAL RESULTS

Moisture and Temperature Conditions:—As a general rule, the moisture content of a soil under a plant-residue mulch is higher than on a soil where the residues were plowed under Soil temperatures usually are lower in the daytime under plant residues. Some typical soil temperature data for daily variations in mulched and unmulched soil are given in Table 1. In this experiment the temperature on mulched and unmulched soil tended to equalize at night. When the weather became colder (sudden change) the mulched soil remained warmer for several hours, or when the weather became warmer the mulched soil remained colder for several hours longer than the unmulched soil. From a consideration of the soil moisture and temperature conditions of a mulched

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[2]The writer is indebted to F. L. Duley, Project Supervisor, for his suggestions and assistance during this investigation and in the preparation of the manuscript.

and unmulched soil, it is to be expected that microbial activity will not proceed at the same rate on the two treatments.

TABLE 1. Soil temperatures on September 11, 1942 at depths of 1 and 4 inches below the soil surface 48 days after 3 tons of wheat straw had been plowed under or left on the soil surface as a residue.

Condition measured	Depth in inches	Temperature in degrees centigrade at different times							
		A. M.		P. M.					
		8:30	10 30	12:30	2:30	4:30	6:30	8:30	10:30
Plowed soil	1	23	28	32	35	33	30	27	26
	4	23	23	25	27	28	28	27	26
Mulched soil	1	23	24	26	28	26	26	25	24
	4	23	23	24	25	25	25	25	24
Air		24	28	30	33	33	32	29	27

SOIL POPULATIONS:—Observations and experiments indicate that during moist weather soil mulched with plant residues may have a considerably larger growth of bacteria, fungi, algae, and mosses at the immediate surface of the soil than plowed land without residues. Immediately after straw residues are plowed under, there is a greater increase in the number of bacteria and fungi than in a similar soil mulched with straw.

On soil straw-mulched for several months during cool, moist weather, the growth of algae and mosses may be considerable. Some patches and areas are so completely covered with algae and mosses that the surface of the soil is quite green. Fungus growth is also noticeable at the soil-residue contact zone during moist weather.

AMOUNT OF PROTECTIVE MULCH CHANGED BY DECOMPOSITION:—Something of the speed of decomposition of crop residues as analyzed by methods previously outlined (6) can be seen from figure 1. After 6 months, approximately one-third of 2-ton applications of cornstalks had decayed; for wheat straw, two-thirds, one-half, and one-third of 2-, 4-, and 8-ton applications, respectively. After 18 months little plant residue was left as protective material with any of the treatments used.

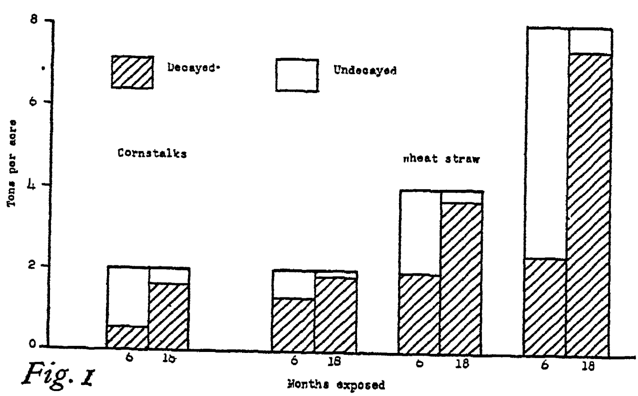

Fig. 1

FIGURE 1.—Two-ton rate of application of cornstalks per acre and different rates of application of wheat straw as shown by height of the columns. The relative amounts of decay after 6 and 18 months are shown by the shaded areas.

NATURE OF MULCH CHANGED BY DECAY:—During the initial stages of decay, wheat straw lost its bright amber color and became darkened (8). Three times as much light was reflected by new as by partially decayed straw under laboratory conditions, as shown in Table 2. Soil under a new 2-ton straw mulch was 2.6° C. cooler than soil under a partially decayed, dark 2-ton straw mulch under comparable experimental conditions using a 100-watt light bulb at a distance of 30 cm. The breaking strength or toughness of new straw was doubled, while the strength of partially decayed straw was not changed by wetting. Decay lowered markedly the breaking strength of straw. These results show that the amount of decomposition determines the heat and light absorption, fragmentation, brittleness, and structural properties of the straw mulch and hence amount of protective material present at any given interval after application.

DECOMPOSITION PRODUCTS OF SOIL MICROORGANISMS AS THEY INFLUENCE SOIL STRUCTURE AND WATER INFILTRATION:—A Peorian loess almost devoid of microbial decomposition products required only 90 ergs per mg. of soil to destroy its structure (5). Under comparable experimental conditions, 1705 ergs per mg of soil were required to destroy the aggregate structure in virgin loessial topsoil with its accumulation of decomposition products, as shown in Table 3.

The Peorian loess, almost devoid of organic matter, when protected by a straw mulch had a total water intake of 3.69 inches during a 3-hour period of sprinkling; when left bare the intake was only 2.34 inches. The topsoil with

TABLE 2. Changes in certain physical properties of straw during early stages of decomposition.

Nature of mulch	Color	Light reflection as candles per sq. ft.	Changes in temperature compared with bare soil – Degrees C	Breaking strength as grams per straw
New straw	light	32	–2 8	4226
Partially decayed	dark gray	11	–0.2	95

TABLE 3. The aggregate stability and total water infiltration on soils with and without microbial decomposition products, and with and without straw mulch.

Soil	Straw mulch Tons per acre	Energy required to destroy soil aggregates. Ergs per mg	Total water intake in inches 3 hours
Peorian loess subsoil	None	90	2.34
	4	....	3.69
Peorian loess topsoil	None	1705	2.49
	4	....	7.96

the microbial decomposition products present, when protected by a straw mulch, had a total water intake of 7.96 inches during three hours; when left bare the intake was 2.49 inches (5). These data emphasize the importance of the soil organic matter in maintaining a high rate of water intake by the soil when the surface was protected with a mulch. However, when the soil was bare the rate of intake was not increased appreciably by the higher amount ot organic matter in the virgin soil. An increased water intake results in decreased runoff and soil erosion.

PRODUCTION OF SOLUBLE NITROGEN:—The pounds of nitrate nitrogen present in 6 feet of soil in plots fallowed from April to September in two different years (7) are shown in figure 2. The nitrate content was lower on the plots

where residues were left at the surface. However, there was ample nitrate nitrogen present for growing a large wheat crop even in the subtilled plots. As a matter of fact, there seemed to be a large surplus of nitrates in all three treatments.

One of the fertility problems of the Great Plains area is the maintenance of organic matter and nitrogen. Continued cultivation, even where erosion was slight, has resulted in loss of one-third of the total nitrogen in 40 to 60 years of cultivation (9, 10). Albrecht (1) has shown that nitrate production on a soil will decrease as a result of cultivation and depleted soil organic matter. Under the present system of plowing and cultivating land, bacterial oxidation of soil organic matter has been speeded up. Generally, the oxidation of soil organic matter to nitrates has not been so rapid with subtillage as with plowing, and this may be a desirable factor in soil organic nitrogen maintenance.

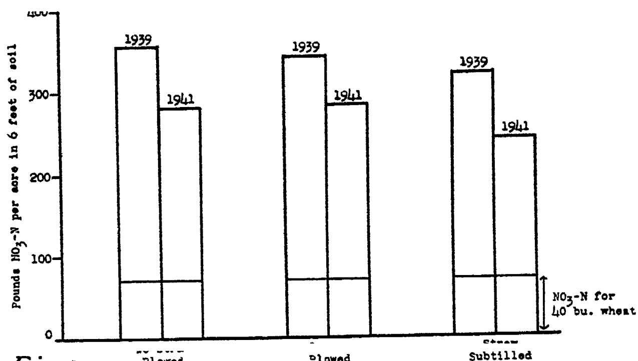

Fig. 2

FIGURE 2.—The nitrate-nitrogen content of land fallowed from April to September. Note the available nitrogen present in all plots in excess of crop requirements.

DISCUSSION

The soil environment of microorganisms under a straw mulch is different from that in the soil farmed by conventional methods. During hot, dry summer days the straw mulch prolongs optimum moisture conditions for microbial activity. It may prevent the soil from reaching the almost sterilizing temperatures of bare plowed land in midsummer and may increase nitrification at that season. There are some periods of the year, particularly during spring and fall, however, when the lowered soil temperature may reduce the rate of nitrification.

Soil population studies under plant residue mulches indicate that the zone of most intense microbial activity is at the point of soil and residue contact, especially during moist weather. Immediately after adding straw residues to the soil, the total number of microorganisms increase more rapidly where the residues are mixed with the soil than where they are left at the surface. This would indicate a more rapid dissipation of the residues by plowing than by subtillage and mulching.

The microorganisms are constantly reducing the quantity and altering the character of the protective cover. Subtilling prolongs the life of the cover as

compared with plowing The mulching material, as decay progresses, becomes more brittle, is broken into shorter pieces, and becomes darker. The change in color modifies soil environment by increasing heat absorption.

Eventually, the microorganisms bring about the decay of plant residues, producing humus which has a marked influence on improving soil structure and increasing water infiltration of the soil when protected with plant residues. This emphasizes the need of retaining the topsoil with its accumulated decomposition products.

As the plant materials decay, the mineral nutrients they contain are liberated to supply plant needs. Since stubble mulching slows down slightly the formation of nitrates during certain seasons, this may prove to be advantageous from the standpoint of soil organic matter maintenance and so far has not been found to limit the nitrate supply sufficiently to decrease crop yields in the Great Plains region.

It now appears possible by the use of subtillage practices, supplemented with plowing where necessary, to exercise a considerable degree of control over the decomposition processes in the field. The decomposition rate of plant residues can be increased to hasten the release of mineral nutrients to the growing crop, or decreased to prolong the life of the protective covering.

LITERATURE CITED

1. ALBRECHT, W. A. 1934. Declining nitrate levels in Putnam silt loam. Jour. Amer. Soc. Agron. 26: 570-574.
2. BENNETT, H. H. 1939. *Soil Conservation*. McGraw-Hill Book Co. New York.
3. DULEY, F. L., and RUSSEL, J. C. 1939. The use of crop residues for soil and moisture conservation. Jour. Amer. Soc. Agron. 31: 703-709.
4. DULEY, F. L., and KELLY, L. L. 1939. Effect of soil type, slope, and surface conditions on intake of water. Nebr. Agr. Exp. Sta. Res. Bul. 112, 1-16.
5. MCCALLA, T. M. 1942. The influence of biological products on soil structure and infiltration. Soil Sci. Soc. Amer. Proc. 7: 209-214.
6. MCCALLA, T. M., DULEY, F. L., and GOODDING, T. H. 1943. A method for measuring the plant fragments of the soil. Soil Sci. 55: 159-166.
7. MCCALLA, T. M., and RUSSELL, J. C. 1943 Nitrate production as affected by grain crop residues on the surface of the soil. Nebr. Agr. Exp. Sta. Res. Bul. 131, 1-21.
8. MCCALLA, T. M. 1943. Changes in the physical properties of straw during the early stages of decomposition. (To be published)
9. MYERS, H. E. 1940. Nitrogen studies on the Western Kansas Branch Experiment Station. Soil Sci. Soc. Amer. Proc. 5: 237. (Abstract)
10. RUSSEL, J. C. 1929. Organic matter problems under dry-farming conditions. Jour Amer. Soc. Agron. 21: 960-967.

3

A Neglected Anatomical Feature of the Foxhall Jaw

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The find, in 1937, of a human occipital and parietal bone in a stratum at Swanscombe, England assignable to the Mindel-Riss interglacial, has aroused debate once more as to the antiquity of men of the *sapiens* type. (1) Similarly the Mount Carmel finds regarded by McCown and Keith as transitional to *sapiens* have been just as reasonably interpreted by others (2) as indicative merely of cross-breeding between *neanderthalensis* and *sapiens*, thus suggesting again, a greater antiquity for the latter.

The Swanscombe fossil lacks the mandible and face as well as the frontal, hence in spite of its suspected *sapiens* affinities, it must remain something of an enigma until more material is recovered. Nevertheless these discoveries serve once more to keep open the problem of our own descent. (3) They justify our keeping at least a casual eye upon certain anthropological "bric-a-brac" from the earlier years which, though never disproved cannot be verified either, and which have been viewed with justifiable suspicion in the past because of a failure to fit into the scheme of human evolution as then conceived.

Such a specimen is the Foxhall mandible from Suffolk, England, a fossil now unfortunately lost, but which, described and illustrated in 1867 (4), was resurrected from oblivion by Reid Moir (5) because of its suspected association with an early Pleistocene cultural horizon in Suffolk. Thereafter it was given some attention by Keith (6), searched for here in America unavailingly by Osborn (7), discussed in the pages of the *American Journal of Physical Anthropology* (8), and dismissed by Hrdlicka (9). Although Thomas Huxley commented that the jaw had "some peculiar characters" (10), he did not, so far as is known, elucidate this comment further.

Nor were any such comments made by following anatomists. Because of the *sapiens* nature of the find, the sharp and pronounced character of the mental eminence (accentuated, however, by the age of the individual and loss of the lower incisors in life), the specimen is generally regarded as being intrusive in the cultural horizon from which it is reputed to have been derived. It was, however, well fossilized. Although the age of the specimen is unproved, it must be remembered that if the present Swanscombe cranium had descended to us through such a curious set of circumstances it, too, would long since have been discarded. Under these circumstances, and so long as the mandibular portion of even the Swanscombe fossil is unknown, a passing comment upon one feature of the vanished Foxhall specimen may do no harm even though admittedly such comment is not advanced with any idea that the authenticity of the fossil can now be established through this means.

The mental foramen, that opening through which the inferior alveolar artery and nerve are permitted to pass mental branches from the mandible to the fleshy portions of the chin, had received comparatively little attention until the time that Weidenreich began his classical description of the mandibles

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of *Sinanthropus* (11). Gregory had recorded a multiplicity of the foramina in the lower primates (12). Simonton had noticed a tendency toward multiple foramina in the higher anthropoids, though the condition was variable (13). In *Homo sapiens,* as is well known, a single foramen is the rule, the opening ordinarily lying just beneath Pm_2. The condition varies, however, quite a number of *sapiens* mandibles showing two foraminal openings, at least on one side. In such cases the association of the two openings is often close. Sometimes there is little more than a dividing sliver of bone across what would otherwise be a single opening. Three openings were noted by Simonton to be markedly rare. In fact in the Caucasian material which he examined he found no instances of three foramina at all, though he found a single instance each amongst his American Indian and negroid material.

It was the attention paid to the incidence of multiple mental foramina by Weidenreich in his study of *Sinanthropus* which stimulated attention to this feature. He succeeded in showing that in *Sinanthropus* the opening was consistently multiple, ranging from two to as high as five foramina. Among other fossil men the Heidelberg jaw is marked by three foramina on the right side, two on the left, while the Neanderthal specimens, including the Mount Carmel Tabun material generally are characterized by two foramina. The Mount Carmel Skhūl types, on the other hand, which approach *sapiens* in many diagnostic features, are characterized by the single foramen marking the typical condition in *sapiens* (14). It would seem, surveying these various studies, that the single foramen to a side is eminently characteristic of *sapiens* and that a possible evolutionary flow has taken place in this direction, markedly reducing and inhibiting the incidence of multiple foramina in modern man.

Now we have previously referred to the somewhat obscure statement of Huxley that the lost Foxhall jaw had "some peculiar characters." In studying the careful line engraving which constitutes our sole information as to the appearance of the missing specimen, the present writer was immediately struck by the fact that the left side of the mandible is clearly featured as carrying *three* foraminal openings several millimeters apart, and arranged in a sort of triangle; two large opening located respectively under Pm_1 and Pm_2 and the third, somewhat smaller and, unlike the other two, directed forward. Intrigued

FIGURE I. The Foxhall Mandible. Redrawn after Collyer.

by this curious feature, the writer consulted the various commentaries upon this specimen but could find no reference at all to the triple foramina which may very well have attracted the attention of the observant Huxley. Seemingly the characteristic has been completely ignored.

It has been indicated above that triple foramina have been noted, albeit as extremely rare, in modern man. We are not justified, therefore, in claiming Pleistocene antiquity for the Foxhall specimen on this basis. We can, however, noting the typical single foramen of the Riss-Wurm Skhūl folk, marvel at the statistical chances involved in the discovery of an individual with triple mental foramina at Foxhall*.

Even if this individual was no more than the product of a Roman burial, as some have insinuated, it carried a physical trait of very sparse occurrence in modern man. One wishes that both sides of the jaw had been illustrated so that there would have been the possibility of comparison.

It may be urged, after this brief review, that more attention be devoted to the mental foramen in reports upon modern and ancient physical remains than has hitherto been the case. The Ice Age antiquity of the lost Foxhall relic is not confirmable. Tantalizing though it is, we must, like Huxley, speak of the mandible's peculiar characters as "not adequate to . . . ascribe the bone to an extinct race" (16). Nevertheless the writer believes that he has demonstrated the genuine existence of one, at least, of those aberrant features which Huxley made bold to mention but never commented upon in print. The Foxhall jaw, whether or not it was of Pleistocene origin, is, in this one visible character, markedly anomalous and rare.

LITERATURE CITED

1. Marston, A. T. *Journal of the Royal Anthropological Institute of Great Britain and Ireland,* 67:339-406, 1937. Report by Royal Anthropological Institute Committee, Ibid, 68: 17-98, 1938.
2. Ashley-Montagu, M. F. *American Anthropologist* n. s. 42:518-522, 1940.
3. Howells, W. D. *American Anthropologist,* 44: 182-193, 1942.
4. Collyer, Robert H. *Anthropological Review,* 5:221-229, 1867.
5. Moir, Reid. *American Journal of Physical Anthropology,* 7:409-416, 1924.
6. Keith, Arthur. *The Antiquity of Man,* Lippincott, Philadelphia, 1932. 1:273-274.
7. Osborn, H. F. *Man Rises to Parnassus,* Princeton University Press, 1928, p. 44.
8. Moir, Reid, op. cit.
9. Hrdlicka, Ales. *American Journal of Physical Anthropology,* 7:420-424, 1924.
10. Cited by Robert Collyer, op. cit.
11. Weidenreich, F. *Paleontologia Sinica, Series D.* 7·28-31, 1936.
12. Gregory, W. K. *American Museum Memoirs,* n.s. vol. 3, pt. 2, 147-148, 1920.
13. Simonton, F. V. *American Journal of Physical Anthropology,* 6·413-421, 1923.
14. McCown, T. D. and Arthur Keith. *The Stone Age of Mount Carmel,* vol. 2, pp. 217, 219, 224. Oxford Press, 1939.
15. Letter reproduced by Robert Collyer, op. cit. p. 223.

*Three foraminal openings have an incidence of 0.19 per cent. More than three openings have never been observed in modern man.

4

Racial And Phylogenetic Distinctions in the Intertemporal Interangular Index

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INTRODUCTION

The percentage which the minimum frontal width bears to the breadth of the skull as taken between the two projecting angular processes (zygomatic) of the frontal bone has received comparatively little attention in the literature of physical anthropology. Sir Arthur Keith noted that the index is lower among the palaeanthropic forms of man and pointed out (1) that due to the fact that the supraorbital torus is reduced in modern man, the difference between the two measurements is less marked. Hence he regards the index as of phylogenetic significance. Keith and McCown in their recent comprehensive survey of the Skhūl material (2) from Palestine reassert this view, but only in passing. Cameron, on the other hand, devotes an entire paper to the subject, and computes the index $\left(\frac{\text{intertemporal width} \times 100}{\text{Interangular width}}\right)$ for several of the extinct hominids as well as for some neolithic and later crania, particularly British. (3) He expresses the view, on the basis of his investigations, that this proportion is usually higher in the female skull and that the index should prove lower in the black races. He further suggests that the transition from the lower index to the higher one of the modern races took place "during the late paleolithic." (4) Cameron's valuable and suggestive survey fails, unfortunately, to exploit three aspects of the problem. Statistically it is inadequate, the range, standard deviation, et cetera, not being recorded because of the inadequate numbers with which Cameron dealt. Second, again because of the dearth of material, he does not deal adequately with possible distinctions in this index between the modern races. Third, where the races overlap in terms of the index, he fails to indicate whether, in terms of per cent of cases, any possible evolutionary trend or tendency can be observed to be manifesting itself among existing groups, and whether the trend may differ in distinct populations.

Inasmuch as the present writer has had access to a much wider range of racial stocks than was available to Cameron, as well as to numbers sufficient for more thorough statistical analysis, it seemed well to pursue this neglected subject somewhat further in the hopes that more extended and reliable data might be placed on record Moreover, from the standpoint of human evolution, additional material had become available since 1934, material which might be worth detailed attention. Under these circumstances, while working under a grant from the Graduate Research Fund of the University of Kansas, at the American Museum of Natural History in New York City, the data given in the present paper were compiled. Since the information was accumulated only as a side venture in the course of a more lengthy study, it is not suggested that the information included exhausts the subject. It is hoped, however, that

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the data collected will make some contribution to our knowledge of a highly variable and significant feature of the facial anatomy of the *Hominidae.*

PREHOMINIDS

The intertemporal-interangular index, to give it the name devised by Cameron, is actually made up of the minimum frontal width (*i.e.* intertemporal width) and the maximum width of the supra-orbital torus (interangular width). In the majority of cases the greatest interangular width of modern man lies at the fronto-malar suture. In the more primitive species of men, and occasionally among rugged modern males, the outer ends of the supraorbital process tend to bulge outward, and hence the measurement at this point is sometimes slightly in excess of the distance measured between the outer borders of the two fronto-malar sutures.

In the present study, as in that of Cameron, no attempt has been made to differentiate between these two slightly different points. The greatest interangular width has been consistently taken irrespective of whether that width fell on the bulge of the supraorbital torus or directly at the fronto-malar suture. The slight variability thus introduced does not greatly affect the results. Moreover, since the development of the torus is of evolutionary significance, its true width is more important to our study than the consistent use of the fronto-malar point, irrespective of whether the latter truly represents the point of greatest width between the interangular processes. In many instances the two points coincide, but not in all. It is likely that there is some slight degree of racial variability in the degree of lateral bulging of the bone immediately above the fronto-malar suture, but the subject was insignificant to the larger study, and was not pursued.

It is important, also, to bear in mind that the index is made up of two separate measurements whose independent variation may strongly affect the index. For phylogenetic purposes, it is not enough, as Cameron more or less implies, to read the index. We must know, in addition, which frontal feature is varying in relation to the other. Otherwise misinterpretation is possible, as we shall demonstrate a little farther on.

The following table gives the available data upon the palaeanthropic races.

TABLE I Intertemporal Interangular Index Figures for Fossil Man

Species	Index
Pithecanthropus erectus	
Skull I	79.
Skull II*	81.25
Sinanthropus pekinensis (1 specimen)*	78.43
Homo rhodesiensis	70 5
Homo soloensis	?
Homo neanderthalensis	
La Chapelle	88.5
Gibraltar	89.
Spy I	85.26
Spy II	88.33
Tabun I	86.72
Galilee	80.67
Neanderthal	85.5
Krapina C.	83.89
Skhūl Intermediates	
Skhūl IV	79.69
Skhūl V	81.14
Skhūl IX	77.41
Homo sapiens fossilis	
Florisbad	88.
Predmost	88.79
Old Man of Cro-Magnon	89 72

Included also, are the Skhūl intermediates and certain specimens of *Homo sapiens fossilis,* including the Florisbad skull. Data for Neanderthal is more consistently available than for the other forms. In two instances (marked by an asterisk) the index has been computed from photographs. The writer, by experiment has found this latter method reasonably accurate, if good pictures are available, but it does not, of course, permit the observation of the actual true measurements involved. All we can obtain in this manner is the index.

The figures in Table I conclusively bear out the views of Keith and Cameron that the index is lower in the palaeanthropic types of mankind. The heavy supraorbital torus of these forms exceeds in width the range for *sapiens,* hence the index is lower. In the case of *H. neanderthalensis* the minimum frontal width keeps pace to some extent with the broad torus. This dimension averages larger than in *Homo sapiens* and hence the index falls into the eighties, a figure which, as we shall note later, is to be observed among some modern races. In the latter case, however, the component measurements from which the index is derived do not approach the Neanderthal values.

Curiously enough, the Skhūl intermediates, regarded by some as marking the transformation of the Neanderthal strain into the species *sapiens,* betray a lower index than the former. This is because the Skhūl frontal bone is of modern proportions, while, by contrast, the angular processes are still very projecting. If the Skhūl folk are regarded as undergoing evolutionary modification instead of representing a hybrid mixture, it would appear that the minimum frontal measurement reached modern proportions before the torus became markedly reduced. On the other hand, the Florisbad cranium from South Africa, regarded by some as *Homo sapiens fossilis,* by others as a South African Neanderthal, has not only the second largest interangular width in the world (the record being held by *rhodesiensis*) but has also a very great minimum frontal width, in which character it is Neanderthaloid. It appears obvious, if this form also is specifically intermediate between *sapiens* and *neanderthalensis,* that the inheritance mechanism involved does not seem to be the same as in the Skhūl cases. Comment is unjustified in our present state of knowledge, but a fuller grasp of the inheritance determiners at work here might aid in ascertaining the real taxonomic status of both the Florisbad and Skhūl folk. It seems odd, if they are both to be deemed transitional forms, that the differences between the two types as regards this character should be so marked.

NEANTHROPIC RACES

We turn now to a survey of a number of existing varieties of *Homo sapiens* —the most extensive survey which, to the writer's knowledge has yet been attempted in connection with this index. Numbers adequate for statistical manipulation were measured, the skulls used being derived from the collections of the American Museum of Natural History in New York, through the courtesy of Dr. Harry Shapiro, head of the Department of Anthropology of that institution. In addition to obtaining the range, mean standard deviation, probable error of the mean, and coefficient of variation, the percentage of individuals whose index ranged over ninety in each group was computed. These data should prove valuable as suggesting the trend of evolutionary flow among the races as regards this character which often varies widely in individual cases even in the same group. The component measurements which

make up the index are also given in the tables so that the separate factors affecting the index can be observed. All figures in millimeters.

MONGOLOIDS. Several Mongoloid groups including Chinese, Eskimo, and Basket Maker Indian remains from the states of Arizona and Utah, are included. It will be noted that considerable differences exist in the index. The Basket Maker II remains from Canyon del Muerto (Arizona) and Grand Gulch (Utah) are as primitive as New Britain and Australian types, as regards this index.

TABLE II

Type	Measurement	No. of cases	Range	Mean p.e.	S.D.	C.V.
Chinese ♂	Minimum frontal	38	82-104	93.29±.54	5.01	5.37
(Southern)	Interangular width	38	97-110	104.66±.45	4.12	3.93
	Index	38	78-97	89.21±.42	3.87	4.33
Eskimo ♂	Minimum frontal	44	90-105	96.39±.37	3.65	3.78
(Point Barrow)	Interangular width	44	102-119	109.40±.37	3.40	3.10
	Index	44	82-95	88.21±.32	3.20	3.62
Am. Indian	Minimum frontal	35	85-103	92.60±.57	5.01	5.41
B.M. II ♂	Interangular width	32	98-114	107.15±.39	3.30	3.07
(del Muerto)	Index	32	79-97	86.66±.47	3.97	4.58
(Grand Gulch)	Minimum frontal	47	84-97	91.27±.31	3.21	3.51
	Interangular width	47	101-110	105.98±.24	2.50	2.35
	Index ♂	47	79-93	86.19±.29	2.97	3.44
	Index ♀	32	80-94	86.18±.42	3.60	4.17

In addition to the variations indicated by the above table, the percentage distribution of the index reveals the following facts: Of the 38 Chinese crania measured, 47.3 per cent had an index of 90 or above. Only one individual had an index of below 80. Of the Point Barrow Eskimo, 36.3 per cent ranged at 90 or above with none falling under 80. Of the Basket Maker crania from Canyons del Muerto and De Chelly, 25 per cent were 90 or above, with one individual falling under 80. For a less heterogeneous collection from Grand Gulch, Utah, 17 per cent were 90 or above, with but a single individual falling under 80. Although, because of limitations in time, no attempt was made to investigate consistently the interfrontal-interangular index of females in all the racial groups examined, a single test run was made in the case of the Grand Gulch females. The results, as evidenced by the table, are at variance with Cameron's claims in connection with the British crania that the index is consistently higher in females because of the less rugged character of the angular processes in that sex. Among the Grand Gulch crania, the indices for males and females are similar down to the second decimal place. The percentage averaging 90 or above was 18.7 per cent, which is only very slightly over the figure for males and could be regarded as no more than a chance variation, due to the sampling. It may be, of course, that sex differences in the index are less apparent among a people with a primitive dietary, but it suggests that even in the case of other groups more extended sampling and analysis might reveal that Dr. Cameron's suggestion cannot be substantiated. Or, again, there may prove to be racial distinctions in regard to sexual variation of the index.

The Basket Maker crania reveal means as low as any existing among modern peoples. In terms of the index alone they fall into the palaeanthropic category. It must be borne in mind, however, that the component parts which make up the index are not as large as in the Neanderthaloids. Only the proportion is similar.

CAUCASIANS. The crania of thirty German males agree favorably with Keith's and Cameron's estimates of the British index. 80 per cent of this group had an index of 90 or above, and it seems quite evident that the Caucasian stock has the highest interfrontal-interangular index of any of the existing races.

TABLE III Caucasoids

Measurement	No. of cases	Range	Mean p.e.	S.D.	C.V.
Minimum frontal	30	90-114	98.70±.65	5.29	5.35
Interangular width	30	96-115	106.03±.52	4.21	3.97
Index	30	88-99	93.03±.33	2.72	2.92

Comparing Table III with the figures given in Table II, it seems evident that a marked increase in the average minimum frontal width is largely responsible for the rise in the index figures.

NEGROIDS. A group of native male crania from the Kamerun of West Africa yielded the following figures. It is to be noted that they do not entirely substantiate Cameron's suggestion that the index will be lower in the black races. It is true that some slight difference exists, but these West African negroes are far from "primitive" in this character.

TABLE IV. Negroids

Measurement	No. of cases	Range	Mean p.e.	S D.	C.V.
Minimum frontal	31	91-106	97.52± 42	3.51	3.59
Interangular width	31	103-116	108 41±.38	3.20	2.95
Index	31	86-96	90 ± 31	2.56	2.84

58 per cent of this group had indices of 90 or above; hence in terms both of percentage and the mean, these West African negroes approach the white stock more closely than do any of the other racial groups examined. The minimum frontal width does not fall much under that of the Caucasoids. The average interangular width, however, is somewhat larger than in the German sample.

NEW BRITAIN. A group of New Britain crania from the von Luschan collection revealed a low index not unsuspected in a people with so many morphologically primitive characters.

TABLE V. Melanesians (New Britain)

Measurement	No. of cases	Range	Mean p.e.	S D.	C V.
Minimum frontal	53	79-103	93.44±.46	5.06	5.41
Interangular width	53	102-115	108.26±.29	3.17	2.92
Index	53	77-96	86 31± 35	3.87	4.44

Probably the index would not vary greatly from that of the Australian Bushmen, whose figure, as given by Keith, is 87.6. Keith does not give the number of his sample. 18.8 per cent had an index of 90 or above, and 5.6 per cent of this sample had an index falling below 80.

CONCLUSION

The data given in the various tables of this paper augment our knowledge of the interfrontal-interangular index among the various races of mankind as follows:

1. There are clearly marked distinctions among the racial groups in regard to this index, but there is a considerable degree of overlap in range as between individuals.

2. The Caucasian stock shows the highest mean index and, judging from percentages, the greatest trend toward the equalization of the two component measurements that make up the index. The expansion of the minimum frontal width seems one of the primary factors involved.

3. The negroid stock runs second to the white in respect to this index with the Mongoloid, as represented by the Chinese, a close third.

4. There is considerable variation among the Mongoloid groups in regard to this feature. Certain of the early American dolichocephals appear to possess the lowest *sapiens* index on record, comparing, in this respect, with such archaic groups as the Australians.

5. The American Basket Maker data suggest that there may not be a sexual distinction in the index among all peoples. More extended data are needed upon this point, and Cameron's views may have to be abandoned in the light of extended statistical investigation.

6. It is plain that several neanthropic peoples, such as the New Britain folk, range completely in the "palaeanthropic" category as regards this index. Though valuable and suggestive from a phylogenetic standpoint, it cannot be used alone, or without reference to its component elements in attempting to establish phylogenetic sequences. The low range in the supposedly intermediate Skhūl crania is indicative of the limitations of the index without reference to the two widths which control the index figure. If this factor is kept in mind, however, the index is seen to have genuine value as a diagnostic racial character. The degree of variation and the standard deviation of the index as well as other data are all available in the tables.

LITERATURE CITED

1. KEITH, SIR ARTHUR *The Antiquity of Man,* Vol. 2, p. 406-407. Lippincott, Revised edition. Philadelphia, 1932.
2. McCOWN, T. D., and KEITH, A. *The Stone Age of Mount Carmel,* Vol. 2, p. 237, Oxford Press, 1939.
3. CAMERON, JOHN. "Craniometric Memoirs, No. VI," *Journal of Anatomy,* Vol. 69, pp. 226-232, 1935.
4. Ibid, p. 228.

5

A Sky-Projection Chart for the Astronomy Class

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A chart which represents a projection of the celestial sphere upon the plane of the horizon has been made by plotting points whose coordinates have been taken from a celestial globe. The coordinates used are azimuth and altitude. The points plotted are the intersections of hour circles and parallels of declination, the latter taken ten degrees apart.

The size of the horizon circle was chosen to fit a large paper protractor

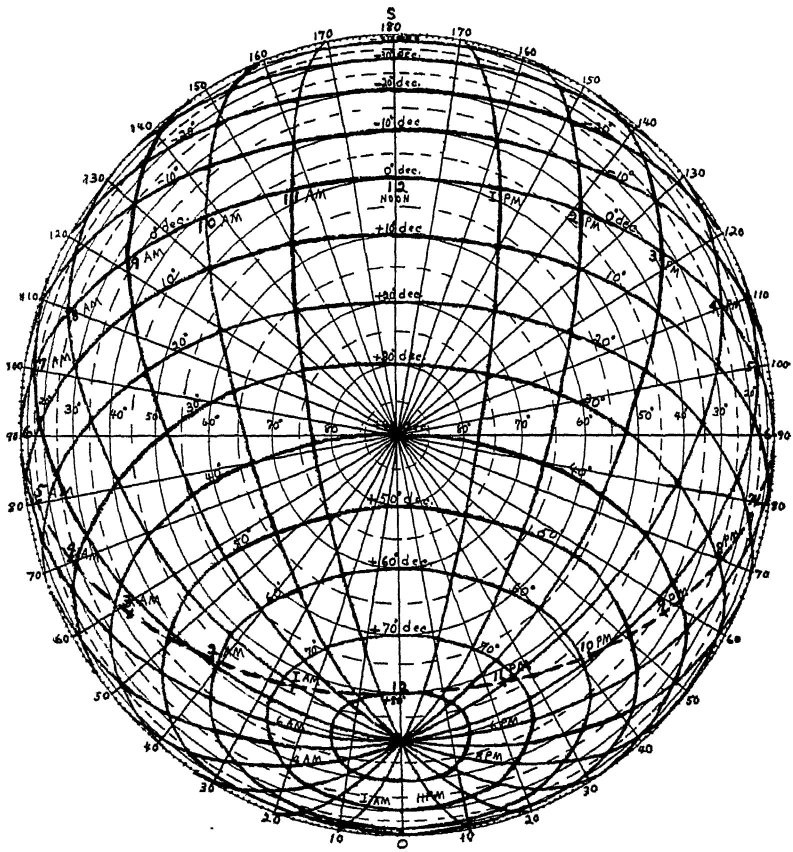

FIG. 1

which was used in marking the degrees of azimuth. The center of the chart represents the zenith for latitude forty degrees north. Radii indicate azimuths at intervals of ten degrees, and concentric circles represent altitudes.

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The radius of each altitude circle is equal to the radius of the horizon circle multiplied by the cosine of the angle of altitude. For example the circle which represents an altitude of ten degrees has a radius of R cos $10^\circ = .985$ R, where R is the radius of the outer circle of the chart.

Table I gives some of the coordinates used in making the chart illustrated by Fig. 1. Although this particular projection of the sky was drawn for latitude 40° N, a similar figure can be drawn for any latitude. In order to get the necessary coordinates, the polar axis of an adjustable celestial globe should be tilted to the desired angle, and the azimuth and altitude of each point desired should then be read from the globe. The azimuths are usually marked on a horizontal frame attached to the celestial globe, and the altitudes may easily be found by aid of a strip of paper calibrated by the degree marks on the globe.

TABLE I. Chart Coordinates.

Hour Circles	Declination of point	Azimuth from north	Altitude	Hour Circles	Declination of point	Azimuth from north	Altitude
1 A.M. & 11 P.M.	70	6	20	8 A.M. & 4 P.M.	60	41	48
"		10	0	"	30	83	41
2 A.M. & 10 P.M.	70	11	22	"	0	111	22½
"		20½	0	"	–20	125	8
3 A.M. & 9 P.M.	60	22	16	9 A.M. & 3 P.M.	60	39	56
"		33	0	"	30	91	52½
4 A.M. & 8 P.M.	60	27	21	"	0	123½	32½
"		48½	0	"	–30	142	8
5 A.M. & 7 P.M.	60	33	27	10 A.M. & 2 P.M.	60	33	62½
"	30	58	8	"	30	102½	63½
6 A.M. & 6 P.M.	60	36	33	"	0	137½	42
"	30	66	18	"	–30	153	14
"		90	0	11 A.M. & 1 P.M.	60	21	67½
7 A.M. & 5 P.M.	60	39	41	"	30	123	74
"	30	74	29½	"	0	156	48
"	0	100	12	"	–30	166	18
"		113	0				

It is possible for inexperienced students to construct a chart of this kind in a few hours, as has been proved by trial in the author's classes. After the points have been plotted, the curves which represent hour circles and parallels of declination can be drawn with fair accuracy by aid of a "French curve". If a commercial "curve" is not available, one may be made out of card board. In this case the edges should be carefully smoothed with sand paper.

Charts made as described above have been used in the author's class to facilitate the study of celestial coordinates, and as an aid in the solutions of problems of the type in which certain coordinates are given and others are to be found. Three problems and the approximate solutions will be given as illustrations of the use of the chart.

1. A star was seen in the north west, at azimuth forty-five degrees west of north, and altitude 48 degrees, at nine P.M. Central War Time, February sixth, 1943, at Baldwin, Kansas. Find the right ascension and declination, and identify the star on a star map.

Solution: The local apparent solar time may be found by making three corrections to the observed time. One hour must be subtracted to get Central Standard time. Next twenty minutes must be subtracted because Baldwin is twenty minutes west of the central meridian. Finally fourteen minutes must be subtracted, since minus fourteen is approximately the value of the equation of time on Feb. 6. When these corrections are made, the local solar time, i.e. the position of the right ascension point of the sun, is 7:26 P.M. Next the

equinox may be located. On Feb. 6 the sun is approximately twenty-one hours east of the equinox, or the equinox is three hours east of the sun. This places the equinox at 4:26 P.M. Having located the star on the chart by its azimuth and altitude, it is found to be near the four o'clock hour circle. Following this line to the equator, the estimated right ascension is thirty minutes. The star is between the fifty and sixty degree parallels of declination on the chart, and the declination may be estimated as fifty-seven degrees N. When a star map is consulted, a fairly bright star in the constellation Cassiopeia is found at right ascension thirty-six minutes, and declination fifty-six degrees N.

2. The star Alpha Ursa Majoris has a right ascension of eleven hours, and a declination of sixty-two degrees. If it were observed at 9 P.M. C.W.T. on Feb. 6, 1943, at Baldwin, Kansas, what would be the azimuth and altitude?

Solution: As in the preceding problem, the equinox is 4:26 P.M. The right ascension point of the star is eleven hours east of the equinox, or 5:26 A.M. This point on the equator is about half way between the fifth and sixth A.M. hour circles. Following these lines northward on the chart to declination sixty-two degrees, the azimuth and altitude may be estimated as thirty-four and thirty degrees respectively. As a check the actual position as observed was: azimuth thirty-five and altitude thirty degrees.

3. The star Regulus (rt. asc. ten hours and five minutes, decl. twelve degrees N) was observed in azimuth 92° and altitude 25°, on Feb. 4, 1943 at Baldwin. What was the time of day?

Solution: By locating the star on the chart, it is found to be between the hour circles seven and eight A.M. By following these lines to the equator, the right ascension point of the star may be estimated as 7:22 A.M. Since the equinox is ten hours and five minutes west of the star, the equinox is placed at 5:27 P.M. On Feb. 4 the sun is approximately 21 hours east of the equinox, or 3 hours west. Thus the sun has its right ascension point at 8:27 P.M., by local solar time. The corrections needed to give Central War Time are the same ones used in problem 1, but with the signs reversed. Adding one hour plus twenty minutes plus fourteen minutes gives 10:01 C.W.T. The time observed was 9:57 P.M.

There are three important factors which affect the accuracy of the solutions of such problems as those given above. The first is the precision of the observations of azimuth and altitude. If eye estimates are made without instrumental aid, errors of several degrees are likely.

The second factor is the relationship between the sun and the equinox. The right ascension of the sun can be found to a high degree of precision in the Nautical Almanac, or the Air Almanac, but this is not necessary. A graph or tabulation of the equation of time for each week of the year should be available. In addition we have the simple rule that the sun progresses two hours of right ascension per month, or roughly half an hour per week. A more exact value may be found by multiplying the number of months from March 21 by two, to get the whole number of hours, and by taking four times the number of days left over, as the number of minutes. For example on Oct. 30 the right ascension of the sun is approximately 14 hours (7x2), plus 32 minutes (8x4). We note that October is the seventh month after March, and that eight days remain after the twenty second. Oct. 22 rather than Oct. 21 is

taken as the end of seven months, because the Autumnal Equinox, which is six months from Mar. 21, usually occurs on Sept. 22.

The third factor which limits the accuracy of a solution is the precision of the chart. This involves the coordinates which have been taken from a celestial globe, and also the mechanical skill of the one who draws the lines on the chart. It has been found by repeated trials that the measured azimuths of points high up on the celestial globe may be in error by one or two degrees.

In spite of these sources of error, problems can be solved by aid of the sky-projection chart with sufficient accuracy to make its use worth while. Even though the right ascension may be in error by half an hour, and the declination by two or three degrees, the identification of a bright star can usually be made with certainty.

6

On the Nature of Forssman Antigen-Antibody Complexes Present in Rabbit Blood

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In a previous paper (7) we described a phenomenon of hemolysin-complement fixation without intervention of antigen and concluded that it was due to a Forssman antigen-antibody complex present in the rabbit blood.

In extending our investigations on the subject, we at first made use of anti-human hemolysin. It is well known that the injection of Type A human blood into the rabbit will produce not only isophile hemolysin against human cells, but also a heterophile hemolysin against sheep cells. In our experiments we studied this heterophile hemolysin by using anti-human hemolysin and sheep cells. In the tubes, in which hemolysin had been added to complement prior to incubation, hemolysis took place only in presence of 0.55 cc of complement diluted 1:10, whereas in the tubes in which hemolysin was added together with

TABLE I

C.	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
HS.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HH.	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Sal/qsl	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
S Cells	0 5	0.5	0.5	0.5	0.5	0.5	0 5	0.5	0.5	0.5	0.5
A	x	x	x	x	x	x	x	x	x	$\underline{x}$	–
B	x	x	x	x	x	x	x	x	–	–	–
C	x	x	x	x	x	x	x	$\underline{x}$	x	–	–
D	x	x	x	x	–	–	–	–	–	–	–
E	x	x	x	x	x	x	x	–	–	–	–
F	x	x	x	–	–	–	–	–	–	–	–

C—Complement 1:10; HS—Pooled negative human serum; HH—antihuman hemolysin, 1:25 (2 units used throughout); S Cells—Sheep Cells, 2%.

A—Complement, human serum and hemolysin mixed and kept in refrigerator for 18 hours. After ten minutes warming in waterbath, cells were added.

B—Complement and human serum mixed and kept in refrigerator; hemolysin and sheep cells added at the same time.

C—Complement and hemolysin mixed and kept in refrigerator for 18 hours After ten minutes warming in waterbath, cells were added.

D—Complement mixed with saline only and kept for 18 hours in refrigerator; hemolysin and cells aded at the same time.

E—Human serum and antihuman hemolysin mixed and kept for 18 hours in refrigerator. After ten minutes in waterbath, complement in usual concentrations and sheep cells were added.

F—Antihuman hemolysin is mixed with saline and kept in refrigerator for 18 hours. After warming for 10 minutes in waterbath, complement and sheep cells were added.

Note—E and F were run in a different day with a different complement.

the sheep cells after the first period of incubation, hemolysis took place with 0.25 cc of complement. It was evident that hemolysin complement fixation resulted in the destruction of 0.3 cc of complement. The addition of human serum to the reaction increased the destruction of complement, since human serum contains a large amount of heterophile complex. Destruction of complement was also very marked when human serum and anti-human hemolysin were mixed together prior to the first period of incubation and complement added later together with sheep cells.

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We repeated all the experiments by replacing sheep cells with human cells, but the results were identical, as invariably there was destruction of a definite amount of complement, when hemolysin or human serum or both were added to complement before incubation.

In order to understand further the nature of the phenomenon, we carried out experiments with anti-sheep hemolysin, which is more easily available at high titer. In one experiment we added glutathione to the rabbit hemolysin with the result that the phenomenon was reversed, that is, hemolysis took place one tube to the left at lower complement concentration in the tubes in which rabbit serum and glutathione had been added to complement before the primary incubation. We have not as yet found a satisfactory explanation of this phenomenon, but we suppose that it is linked with oxido-reduction processes. We noted also that the dilution and preservation of rabbit serum in a buffer solution containing 0.5% phenol attenuated the phenomenon of complement fixation, possibly because phenol destroys part of the Forssman antigen-antibody complexes.

Various Wasserman and bacterial antigens were also tried. The addition of Wasserman antigen helped destroy a small amount of complement, but, when rabbit serum and antigen were incubated in separate tubes and then mixed with complement just before adding sheep cells, the results were the same as when antigen had not been added. As bacterial antigens, we used young cultures of *Salmonella Schottmueller; Eberthella typhi,* Proteus X19, *Shigella paradysenteriae* FlexnerY, all grown on Tryptose agar for 24 hours, suspended in saline, killed by heat and, after centrifuging and washing, resuspended in dilute hemolysin. After a contact of one or two hours, the bacteria were centrifuged and the supernatant fluid used in our tests. It is known that injections of Salmonella into the rabbit stimulates the production of heterophile hemolysin for sheep cells. In our experiments the hemolysin which had been absorbed with Salmonella gave a stronger fixation of complement. The same happened when, instead of hemolysin, saline was used to make a light suspension of bacteria and, after centrifugation, the supernatant fluid added to the reaction tubes together with hemolysin.

With typhoid antigen, the results were unchanged either way; that is, the phenomenon was neither strengthened nor attenuated. With Proteus and Flexner antigens the phenomenon disappeared, indicating that these bacteria contain an antigen which will absorb the heterophile antibodies and prevent them from fixing complement. Proteus X19H showed, in addition, some hemolytic activity.

In one experiment we used a typhoid suspension and a human serum containing anti-O and anti-H agglutinins at a titer 1:60. The mixture of anti-serum, typhoid bacilli and hemolysin destroyed a certain amount of complement, but the same results were obtained also when hemolysin was added with the sheep cells. Further, we mixed complement, anti-serum and typhoid suspension and left the mixture for four hours in the refrigerator. The mixture was then centrifuged, and the supernatant fluid containing complement used in the test. Although the complement proved to be extremely weak, it still contained a fraction specifically destroyed by hemolysin and rabbit serum. The sediment was washed to eliminate traces of both human and guinea pig serum, and the flocculate containing the bacteria and whatever other substances may

have been absorbed by them, was used as an antigen. The flocculate added to our hemolysin-complement fixation experiments did not inhibit our phenomenon, but only helped destroy a larger amount of complement.

TABLE II

C.	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0 4	0.45
H.	0.2	0 2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Floc.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sal qs	1.	1.	1.	1.	1.	1.	1.	1.	1.
Cells	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0 5	0.5
A	x	x	x	x̲	–	–	–	–	–
B	x	x	x̲	–	–	–	–	–	–
C	x	x	x	x	x	x	x	x	x̲
D	x	x	x	x	x	x	x	x̲	–
E	x	x	x	x	x̲	–	–	–	–
F	x	x	x	x	x	x̲	–	–	–
G	x	x	x	x	x̲	–	–	–	–
H	x	x	x	x	x	x̲	–	–	–
I	x	x	x	x	x̲	–	–	–	–
J	x	x	x	x	x	x	x	x	x̲
K	x	x	x	x	x	x	x	x̲	–

C—Complement, 1:10; H—Hemolysin, 2 units throughout; Floc.—Flocculate, according technique given in the paper.
A—Complement, hemolysin mixed and kept in refrigerator for 18 hours. After warming the tubes in waterbath for 10 minutes, cells were added.
B—Complement mixed with saline and stored in refrigerator; hemolysin added with the cells.
C—Typhoid antigen and anti-H and anti-O serum mixed and left standing for ½ hour, then centrifuged and washed Complement added and left another ½ hour, then centrifuged and used in the usual dilution in the test in place of fresh complement. Mixed with hemolysin and kept for 18 hours in refrigerator and then warmed for 10 minutes in waterbath before adding the cells
D—Complement prepared as in C, mixed with saline only and kept in refrigerator for 18 hours. After warming in waterbath for 10 minutes, hemolysin and cells were added
E—Complement, typhoid antigen and antiserum, hemolysin mixed and kept for 18 hours in refrigerator After warming in waterbath for 10 minutes, cells were added. (The same results are obtained, when hemolysin is added with cells. Typhoid antigen and anti-serum are added in amount of 0.1 each)
F—Flocculate and hemolysin mixed together and kept for 18 hours in refrigerator. After warming in waterbath, cells and complement were added.
G—Same as F, except that hemolysin is added with the cells.
H—Complement, hemolysin, flocculate mixed and kept in refrigerator for 18 hours. After warming in waterbath, cells were added.
I—Same as H, but hemolysin was added with cells.
J—Complement prepared as in C, flocculate and hemolysin mixed and kept in refrigerator for 18 hours. After warming in waterbath, cells were added
K—Same as in J, except that hemolysin was added with cells

In another experiment we treated hemolysin with ether, to extract any ether-soluble substances. After a prolonged extraction, the ether was decanted and the hemolysin filtered through gauze. Neither the titer of the hemolysin nor the phenomenon was disturbed by ether extraction, which clearly indicated that both these properties of the hemolysin were not linked to lipoid substances.

The absorption of hemolysin with boiled beef cells, as suggested by Davidsohn (3) for heterophile antibodies, eliminated the phenomenon, confirming our former conception that this last behavior is due essentially to Forssman antigen-antibody complexes. The same was true when highly diluted beef serum was added to the reaction, indicating that the same antigen capable of absorbing heterophile antibodies is present in both serum and cells of beef blood. The beef serum is very rich in Forssman antigen-antibody complexes. Even diluted 1:1000, it was able to fix small fractions of complement without necessitating the addition of rabbit serum.

With the idea that perhaps the polysaccharide fraction might have been responsible for the phenomenon of complement fixation we proceeded to extract the polysaccharide from rabbit hemolysin and non-immune rabbit serum. This procedure not only rendered the hemolysin ineffective, but also introduced strong anticomplementary substances in the reaction.

Next we absorbed the rabbit hemolysin with kaolin. The hemolysin was considerably weakened by kaolin, but, when used in our tests in double amounts, the phenomenon persisted, indicating that the kaolin absorption is non-specific and does not eliminate heterophile antibodies.

Fresh guinea pig serum was extracted for three days with alcohol and then diluted 1:20 for our experiments. The sediment left after the extraction was resuspended in saline and used also to verify whether guinea pig serum contained fractions playing a role in the phenomenon. It was observed, when either the alcohol or the water fraction was added to complement previous to first incubation, that a small fraction of complement would be destroyed as in the case of addition of hemolysin. However, by allowing the mixture of hemolysin and alcoholic or water extract of guinea pig serum to stand overnight and by adding complement to it just prior to the addition of sheep cells, no fixation of complement was demonstrable. In this case, we must point out that we did not allow time to elapse between the addition of complement and that of sheep cells, and we believe the results should be rechecked before drawing any conclusion on the presence or absence of a specific antigen in the guinea pig serum.

In a last series of experiments we employed a number of enzymes and amino-acids. We will not discuss the various steps and methods of investigations, because of the necessity of brevity. In some tests the enzymes were added in traces to the hemolysin and used as such in our experiments; in other tests, after a variable period of time from one hour to several hours, the enzymes were destroyed by heating the suspensions at 56° C. Lipase seemed to attenuate the phenomenon, however, without suppressing it entirly; trypsin and pepsin, which ultimately destroyed the hemolysin, had no influence on the phenomenon. Amylase also does not affect the phenomenon but on account of its complex action, it will be discussed in detail in another paper. The action of pangestin cannot easily be analyzed on account of the heterogeneity of the enzyme.

Other experiments were carried out by combining various enzymes of amino-acids. Lipase alone attenuated the phenomenon, but the association of lipase with trypsin or cystine increased the amount of complement fixed. Tyrosine was without influence either way and glutathione associated with lipase seemed to have the same action as cystine.

From these experiments, which are by no means complete, we have concluded that the rabbit serum contains Forssman antigen-antibody complexes which are capable of fixing a certain amount of complement. Some bacterial antigens, as well as beef serum and boiled beef cells, are capable of absorbing the antigen-antibody complexes. The action of enzymes is variable, but, in general, only lipase is capable of attenuating the phenomenon. The antigen-antibody complex is linked with a protein, as evidenced by the fact that it is not extracted with ether; it is not present in the polysaccharide fraction and is destroyed by any substance which denatures protein completely or partially.

BIBLIOGRAPHY

1. COMBIESCO and others: Presence des anticorps heterophiles dans le serum humain normal and pathologique, Compt-Rend. Soc. Biol. 104:1147, 1930.
2. COULTER: Protein associated with hemolysin in rabbit serum and plasma, J. Gen. Phys., 10:545, 1927.
3. DAVIDSOHN: Heterophile antigen in human blood, Arch. Path. 6:32, 1928.
4. DEISSLER: Zur Kentniss der sogenannten Komnonenten des Komplements, Ztschr. f. Imm. 73,365, 1931, 1932.
5. FRIED, GRUENBAUMS Zur Frage u. den Gehalt der Tierorganen an heterogenen Antigen, Ztschr. f. Immunitätsforschung u. exp. Ther. 52, 50, 1927.
6. GAHL: Quantitative studies on the action of compound hemolysins, J. Imm. 16, 209, 1929.
7. GERUNDO and GOLD: Influence of Forssman antigen-antibody complexes on the hemolytic system, Med. Rec., 155, 195, 1942.
8. HOMIYA: Zur Analyse des A Rezeptors des Hammels, Ztschr. f. Imm., 67, 319, 1930.
9. KRITSCHEVSKI: U. heterogenen Komplementbildende Antikoerper, Ztschr. f. Imm.-forsch. 52, 339, 1927.
10. TANIGUCHI: Studies on heterophile antigen and antibodies, J. Path. and Bact., 24, 217-254, 1921; and 24, 456, 1921.
11. YANAGHISHI: On antihemolytic action of immue sera, J. Imm. 15, 421, 1928.

(This bibliography applies also for the following paper on *Complement.*)

7

Some Investigations on the Probable Enzymatic Nature of Complement

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Much has been said about the nature of complement, as is usually the case concerning things about which we know little. Perhaps our investigations do not add any new knowledge, but we hope they will focus attention upon some aspects of the problem which have been overlooked by recent workers in the field.

We began first to use enzymes in connection with our investigations (7) on the nature of the Forssman antigen-antibody complexes of rabbit blood, but we soon became aware that the enzymes had a definite influence upon the complement. The enzymes used were lipase, pepsin, pangestin, trypsin, and amylase. Pangestin, of course, is a mixture of pancreatic enzymes and its action is complex on account of their conflicting activities.

In our first series of investigations we added each enzyme directly to the hemolysin, but it was soon noted that the action varied not only with the enzyme used, but also with the length of time it had been allowed to act. We

TABLE I

C.	0.05	0.1	0.15	0.2	0.25	0.3	
H.	0.3	0.3	0 3	0.3	0.3	0.3	(Two units)
Cells	0 5	0.5	0.5	0.5	0.5	0.5	
A	x	x	–	–	–	–	
B	x	–	–	–	–	–	
C	x	x	–	–	–	–	
D	x	x	x	x	x	x	
E	x	x	–	–	–	–	

A—Antisheep hemolysin; B—Hemolysin to which lipase has been added; C—Hemolysin to which pangestin has beed added; D—Hemolysin to which pepsin has been added; E—Hemolysin to which trypsin has been added.
Each hemolysin is in separate tubes with complement. Incubation for ½ hour at 37° C.

noted that lipase reinforced the hemolytic action to such a degree that hemolysis took place with a smaller amount of complement. Pangestin, when recently mixed with hemolysin, showed an action similar to that of lipase, but to a more moderate degree, no doubt on account of some lipase present in it. Pepsin, whether acidified with hydrochloric acid or without any acid, after one hour of contact with hemolysin, suppressed hemolysis entirely; trypsin did not inhibit hemolysis entirely, but it required a larger amount of complement to produce full hemolysis. It seemed to us that hemolysin is probably linked with complex proteins, upon which pepsin acts first by splitting them into simpler compounds, and, therefore, destroying any hemolytic activity; whereas trypsin acts upon proteins already split by pepsin and much more slowly upon complex proteins. Indeed, when trypsin is allowed to act for several hours or overnight, its action is undistinguishable from that of pepsin.

The action of lipase on hemolysis is certainly due to the activity of the enzyme, because, by heating the hemolysin containing lipase at 56°C for 20 minutes, the enzymatic action may be destroyed and, with it, the favorable

influence upon hemolytic activity. The same is true for the other enzymes, whose activity is suppressed by heating them at 56° or 60° C.

In order to eliminate the possibility that the action of lipase might have been due to a slight hemolytic action of the enzyme, we set up several controls, one including lipase, hemolysin and sheep cells, another lipase suspension and sheep cells, and still another complement lipase and sheep cells. In none of the three instances did hemolysis take place, clearly indicating that the enzyme had no hemolytic activity whatsoever when added alone either to hemolysis or complement.

In a second series of experiments we added the enzymes directly to complement. The tubes containing complement and lipase showed the same type of reaction, that is, complete hemolysis with smaller amounts of complement; the tubes containing pepsin showed no hemolysis whatsoever, as was to be expected. The tubes containing pangestin and trypsin also showed no hemolysis, in contrast to our results with the same enzymes added to hemolysin. This result certainly proved either a greater liability of the complement or a difference in structure, which makes it easier for trypsin and pangestin to attack the molecular structure of complement than to attack that of hemolysin. Perhaps the thermolability of the complement is dependent upon this more delicate structure.

TABLE II

C.	0.05	0.1	0.15	0.2	0.25	0.3	
H.	0.3	0 3	0.3	0.3	0.3	0.3	(Two units)
Cells	0.5	0.5	0.5	0.5	0 5	0.5	
A	x	–	–	–	–	–	
B	–	–	–	–	–	–	
C	x	x	x	x	x	x	
D	x	x	x	x	x	x	
E	x	x	x	x	x	x	

A—Fresh complement; B—complement to which lipase has been added; C—Complement to which pangestin has been added; D—Hemolysin to which pepsin has been added; E—Hemolysin to which trypsin has been added.
Each complement is in separate tubes with hemolysin Incubated for ½ hour at 37° C.

In the tubes in which lipase was added to both complement and hemolysin and left to act for variable times (from 1 to 2 hours), hemolysis fell at exactly the same tube as when lipase was added only to one of the two. However, when lipase was left to act for 5 hours or more, hemolysis took place either at higher complement concentration or not at all. As for every other enzyme, there is for lipase an optimum of time which cannot be overlooked with impunity. Lipase, added to complement inactivated at 56° C and to old complement which had already lost all its activity, did not restore normal hemolysis.

In combining lipase and trypsin, the results were the same as those in which trypsin had been added alone to the complement; their combined action paralleled that of pangestin, of which they are essential constituents. Cystine alone, or combined with lipase, did not influence the complement either way. The same was true for tyrosin and for glutathione, alone or in combination with lipase, as well as for various combinations of cystin and glutathione, tyrosine and cystine, and tyrosine and glutathione.

The most interesting results were, however, obtained with amylase. At the beginning, as with other enzymes, we added amylase to the hemolysin and noted that hemolysis took place first in those tubes which contained less hemolysin. Following this finding, we added the amylase to complement and noted that

hemolysis took place in all the tubes, and that even when hemolysin was omitted, hemolysis took place just the same. Considering that perhaps amylase itself contained some hemolysin, we used, then, amylase suspension alone, but hemolysis did not take place at any concentration. We found also that, to a very limited extent, amylase would work with old complement that had not entirely lost its activity, but it had almost no influence with inactivated complement. Amylase acted like an ideal hemolysin, as the same results were obtained whether sheep, beef or human cells were used.

To a certain extent, amylase acted like snake venom, which needs complement to be activated. Indeed, it is possible that the difference between snake venom and other animal salivas, including human saliva, is only of degree between species. If we are permitted a humorous digression, we might even go farther and point out that this difference may exist between individuals, because the saliva of some humans seems to be more poisonous than that of others.

The action of amylase is also related to time, as it is more intense from one half to one hour after mixing and decreases gradually so that after several hours it will definitely hinder hemolysis. Calcium chloride added to the saline solution in the proportion of 1:1000 enhanced the action of amylase. A pH of 8 not only increases the hemolytic activity, but also accelerates hemolysis. A note of caution, however, must be injected at this point. We have found that our samples of amylase have deteriorated rather promptly and finally become useless for our investigations.

Since lipase had reinforced the action of complement, we tested the combination of lipase with amylase, in an endeavor to find an artificial hemolysin, which could have both complementary and hemolytic activities combined. However, the results were disappointing, as the combination of amylase and lipase gave no hemolysis even when complement was added to it. If not antagonistic, lipase and amylase, at any rate, did not seem to be synergistic.

The addition of glutathione, cystine, cysteine and tyrosine to complement were without notable influence. Cholesterol, added in the same amount as in any Wasserman antigen, did not prevent hemolysis, but only made it slower, as the time required to reach complete hemolysis was much delayed. Lecithin showed an action entirely opposite to that of cholesterol, inasmuch as it shortened the time of hemolysis, but, like cholesterol, it did not influence the amount of complement required for complete hemolysis in one hour.

In another experiment we combined saponin and amylase in presence of complement. The amount of saponin added was such that it would not hemolyze the cells even after prolonged contact. When amylase was added, hemolysis took place in all tubes, even those in which amylase alone, because of the minimal amount of complement present, would have been unable to produce any hemolysis at all. The two substances appeared to be definitely synergistic, and acted only in presence of complement.

It was found in successive experiments that hemolysis could be made more pronounced by sensitizing the cells with amylase, and then adding complement. Although amylase alone was unable to hemolyze the cells, the addition of complement resulted in prompt hemolysis.

Finally, we carried out certain experiments in order to determine whether there are multiple complements according to the original conception of Ehrlich.

(Note—this concept is not to be confused with the idea of multiple components, which seems definitely established). We had noted (7) that, whatever the amount of rabbit serum or other heterophile antibody added to the test tubes, the amount of complement fixed was almost invariably the same. Perhaps there is in the guinea pig serum one type of complement or one species of complement which would be fixed specifically by heterophile antigen-antibodies.

To determine the effect of partial fixation by isophile antigen-antibody complex, prior to the fixation by the heterophile complex which we have previously discussed, we used typhoid antigen and an anti-H and anti-O serum, having a titer of 1:60. By varying the conditions of experiment, we noted that, when antiserum, typhoid antigens and hemolysin were mixed at the same time and incubated for two hours at 37° C, only a certain amount of complement would be destroyed. However, when complement, typhoid antigen and

TABLE III

C.	0.05	0.1	0.15	0.2	0.25	0.3	0.35
Typh.	0.1	0.1	0.1	0.1	0.1	0.1	0.1
H-O-S	0.1	0.1	0.1	0.0	0.1	0.1	0.1
H (2 un.)	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Saline	1	1.	1.	1.	1.	1.	1.
Cells	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A	x	x	x	x	x	–	–
B	x	x	x	x	–	–	–
C	x	x	x	x	x	–	–
D	x	x	x	x	x	–	–
E	x	x	x	x	x	x	–
F	x	x	x	x	x	x	–
G	x	x	x	x	x	x	–
H	x	x	x	x	x	–	–
I	x	x	x	x	–	–	–

C—Complement; Typh—Typhoid antigen; H-O-S—Human serum containing anti-O and anti-H agglutinins (1:60); H—Hemolysin; Cells—2% sheep cells.

A—Complement and hemolysin mixed together and incubated for two hours, after this period cells were added.

B—Complement and saline incubated for two hours; hemolysin added with cells.

C—Complement, H-O-S, typhoid antigen and hemolysin mixed and incubated for two hours; after this period cells were added.

D—Same as C. except that hemolysin was added with cells.

E—Complement, H-O-S and typhoid antigen mixed and incubated. After 1 hour, hemolysin was added and the whole incubated for one hour more before adding cells.

F—Complement, hemolysin mixed and incubated for one hour; H-O-S and typhoid added and the whole incubated for 1 hour more before adding cells.

G—Complement, typhoid antigen and hemolysin mixed and incubated for 1 hour; H-O-S added and the whole incubated for 1 hour more before adding cells.

H—Complement, H-O-S and hemolysin mixed and incubated for 1 hour; typhoid antigen added and the whole incubated for one hour more before adding cells.

I—Complement, H-O-S mixed and incubated for one hour; hemolysin and typhoid antigen added and the whole incubated for one hour more before adding cells.

anti-serum were mixed together at the beginning of the first hour and hemolysin added at the beginning of the second hour of incubation, the amount of complement destroyed was one fraction of 0.05 cc. more than in the first example. However, it was noted also that, when hemolysin was added to complement at the beginning of first hour and typhoid antigen and antiserum added at the beginning of the second hour, 0.05 cc. of complement was destroyed in excess of the amount destroyed by mixing typhoid antigen, anti-serum and hemolysin before any incubation. The same results were obtained by replacing the first hour of incubation with four hours refrigeration and the second hour by overnight refrigeration.

From the results given above we cannot conclude definitely that complement is an enzyme or a complex of enzymes. We have presented here some facts which seem to show some connections between enzymatic action and hemolysis

by complement and hemolysin, and we have pointed out the possibility that further investigations may demonstrate similarities between complement and digestive enzymes. We shall feel satisfied if we have only stimulated scientific interest in this fascinating subject; we ourselves are enlarging our investigations with the hope that we shall reach some conclusion about the multiplicity of complements.

For bibliography see the preceding paper by Gerundo and Gold, page 74.

Acid Liquid Media for the Isolation of Fungi

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Acidified fluid media for the primary isolation of fungi (1, 2) are so poorly buffered that bacterial growth develops when large inocula are employed routinely. Two liquid media, well buffered at pH 4.0 to 4.4, have been developed for the routine isolation and culture of fungi from sputa, gastric lavage specimens, tissue biopsies, pus, and secretions from human sources.

MEDIUM A

250 ml tapwater
10 g glucose
1 ml sodium lactate (10 per cent solution)
1 ml methyl red (0.4 per cent alcoholic solution)
citric acid (M/10) add until a deep pink endpoint is reached (pH 4 0, approximately)
0.5 g Bacto-tryptose; added after adjustment of pH.

Dispense to large test tubes or small Erlenmeyer flasks; steam for 15 minutes and store at room temperature.

MEDIUM B

Inoculate one liter of sterile skimmilk or reconstituted skimmilk (10 per cent) with *Streptococcus liquefaciens* or *Streptococcus zymogenes*. Incubate at 37° C. until extensive proteolysis occurs, usually five to seven days. Filter the mass culture thru thin layers of absorbent cotton and gauze. If a clearer filtrate is desired, mix the mass culture with Filter-Cel (Johns-Manville Corp.) and remove the liquid portion by suction thru a Buchner funnel fitted with a canvas mat covered by a uniform thin layer of moist Filter-Cel. To the filtrate recovered, add an equal volume of tapwater. Supplement the medium with five per cent glucose. Then proceed with tubing and heating as indicated for *medium A*.

DISCUSSION

Medium A has been employed as the chief liquid medium in a series of 235 mycological examinations (3). It was found to be a most favorable medium for the initial growth and routine isolation of *Coccidioides immitis, Trichophyton rubrum,* various *Monilia sp.,* and saprophytic fungi. Preliminary results with *medium B* reveal that its cultural properties are equivalent to those of *medium A;* however, *medium A* is a medium of choice for isolation and successive culture because of its greater clarity and ease of preparation.

REFERENCES

1. YEGIAN, D., and J. M. KURUNG. Dextrose yeast extract medium for the isolation of fungi from sputum. J. Lab. Clin. Med. 26: 1195-1197, 1941.
2. PEPPLER, H. J., and M. J. TWIEHAUS. Equine sporotrichosis Trans. Kansas Acad. Sci. 45: 40-46. 1942.
3. PEPPLER, H. J. Routine procedures for the isolation and identification of certain pathogenic fungi. Am. J. Clin. Path. In Press.

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Prairie Studies in West-Central Kansas, 1942

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For many years the pasture land of west-central Kansas has been observed to fluctuate greatly in the amount and kind of vegetation covering the soil (Albertson and Weaver, 1942). With this great variation in basal cover and composition it was obvious that great differences in yield must also have occurred. Specifically, what do pastures actually yield under different types of plant cover? It is the purpose of this paper to report on the yield of prairie grasses on the various grazing types common to this section of the state of Kansas.

Three tyes of native vegetation occur widely in the loam soils of west-central Kansas These are the disclimax short-grass community of the more level and gently rolling lands; the little bluestem (*Andropogon scoparius*) type of steep hillsides where rock outcrops occur or where rock is covered only by a shallow soil; and the big bluestem (*Andropogon furcatus*) type of deep ravines and lowlands which are supplied with run-in water and thus receive more moisture than is afforded by the local precipitation (Albertson, 1937).

Stockmen and others are much interested as to the productivity of each type in terms of increase in weight of grazing animals per unit area grazed. Since the amount of forage produced is an important factor in determining the answer to this question, the following study was made at Hays in 1940, 1941, and 1942

Barbed wire exclosures were placed on representative areas of each type and 20 meter quadrats were staked out in each exclosure. These were all in the same 750-acre pasture and consequently had been subjected to the same moderate degree of grazing in past years. The vegetation was charted and clippings were made at a height of one half inch. The forage was divided into short grass, mid grass, forbs, and weeds. It was air-dried and the yields expressed in pounds per acre.

ENVIRONMENTAL CONDITIONS

The accumulated rainfall deficit during the period of drought which extended from 1933-1939 inclusive amounted to approximately 35 inches. Precipitation during 1939 was only 15.85 inches (Figure 1). The severe drought which extended far into the fall caused the death of much of the vegetation that had thus far survived the drought; consequently the cover of native plants was nearly zero in the spring of 1940.

Precipitation during 1940 amounted to nearly 23 inches. Even though nearly normal, this was insufficient to bring about any great recovery to the drought-stricken vegetation. Environmental conditions were further improved during 1941 when the total precipitation for the year was slightly more than 28 inches. Growth of vegetation including annual weeds was greatly increased during the growing season of this year. Many badly deteriorated pastures became densely covered with such annual weeds as pepper grass (*Lepidium*

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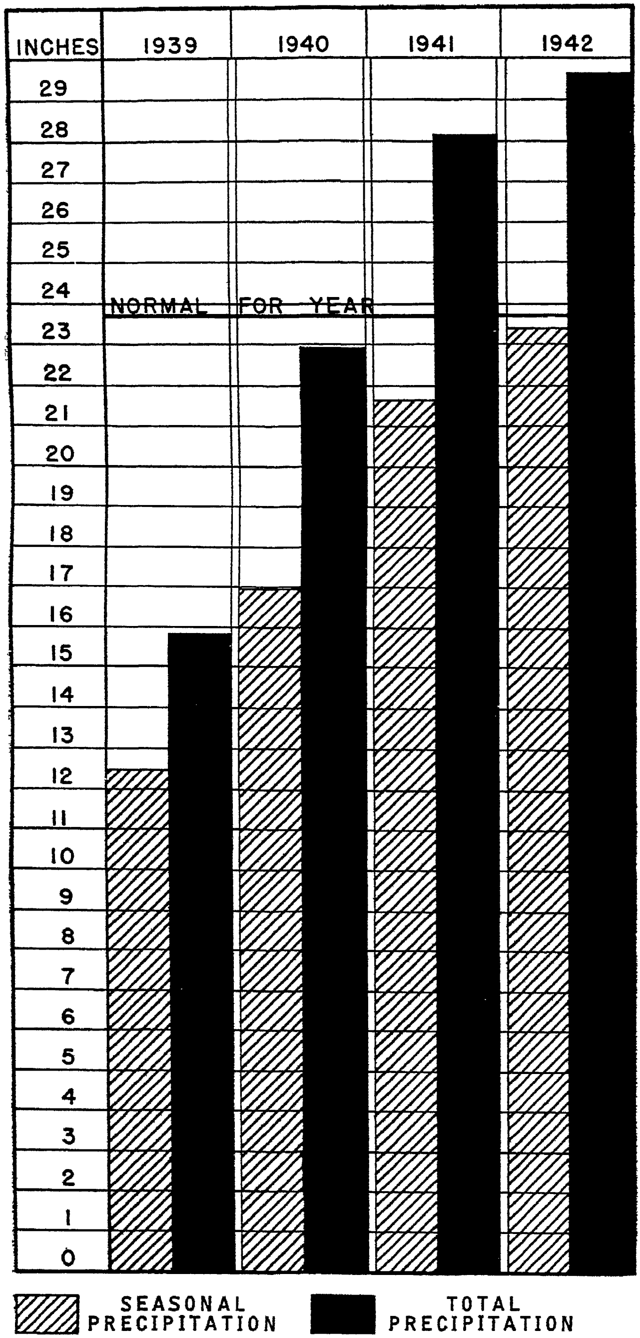

FIGURE 1. Precipitation at Hays, Kansas, for entire year and for growing season.

densiflorum), stick tights (*Lappula occidentalis*), lambs quarters (*Chenopodium spp.*), pig weeds (*Amaranthus spp.*), and Russian thistle (*Salsola pestifer*). Precipitation during 1942 amounted to nearly 30 inches or approximately 7 inches above normal. This increased precipitation added greatly to the supply of soil moisture and growth of the prairie vegetation was somewhat proportional to the increase in available soil moisture.

BASAL COVER AND YIELD IN THREE GRAZING TYPES

Short Grass Type

The average basal cover in the short grass type in the fall of 1940 was slightly over 20 per cent (Fig.2). The total yield of short grass for the growing season was 538 pounds per acre. By 1941, the cover had increased to about 43 per cent, and 902 pounds of forage were harvested. In 1942 the cover had further increased to 83.7 per cent and yielded 1650 pounds of short grass or nearly 3 times the yield in 1940. This open type of cover, common everywhere during the drought years, was conducive to the growth of many weedy annuals such as *Hordeum pusillum, Lepidum densiflorum,* and *Lappula occidentalis.* These were fully grown by the end of May and were all included in the first harvest since there was no recovery from clipping. The amount of weeds in 1940 was 433 pounds per acre. It was 2085 pounds in 1941, but only 1400 pounds in 1942.

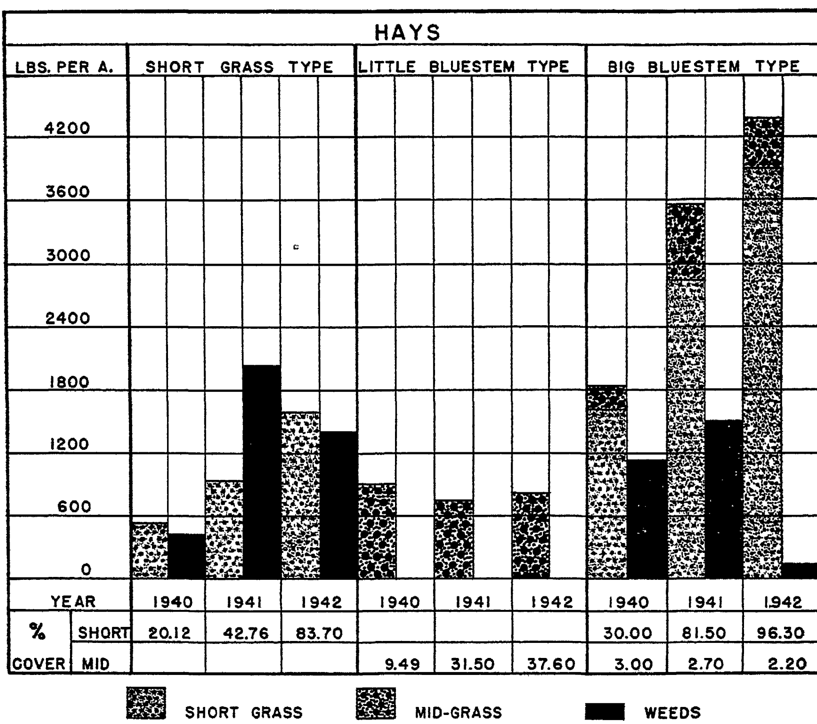

Figure 2. Pounds per acre of grass and weeds on short grass type, little bluestem type and big bluestem type at Hays, Kansas.

Little Bluestem Type

The basal cover in the little bluestem type was about 9.5 per cent in 1940. Production of 915 pounds per acre of mid grass, mostly side-oats grama, was secured. The yield decreased to only 650 pounds in 1941, although the basal cover had increased to 31.5 per cent, an effect doubtless due to the frequent clipping since the season was very favorable to growth. In 1942 the yield increased slightly to 824 pounds from a cover of 37.6 per cent. The rocky, shallow soil common to this grassland type appears to be unfavorable to the growth of annual weeds of which only a few grams were harvested during each year.

Big Bluestem Type

The pre-drought cover on the big bluestem type had been materially changed by drought and grazing during the dry cycle. The short grasses (mostly buffalo grass) formed a rather continous layer beneath the taller mid grasses which were chiefly *Agropyron smithii* and *Bouteloua curtipendula,* most of the big bluestem and other tall grasses having died. The cover of the short grass in 1940 was 30 per cent, but that of the mid grass only 3 per cent. The yield of short gass was 1638 pounds and that of mid grass 187 pounds per acre. Weeds, consisting primarily of Hordeum pusillum, yielded 1,128 pounds the first year. The cover of short grass had greatly increased during the second year, and was 81.5 per cent in the fall of 1941. That of the mid grass, which was slightly reduced, was 2.7 per cent. Yields were 2,762 and 675 pounds, respectively. The yield of weeds was 1,448 pounds. The cover of short grass in 1942 had increased to 96.3 per cent from which a yield of 3896 pounds per acre was harvested. The cover of mid grass had decreased to 2.2 per cent and the yield was 483 pounds per acre.

The drought had profoundly changed the vegetation in all three types, and it is now under going recovery toward its pre-drought condition (Weaver and Albertson, 1943). Consequently these data will not pertain to past and probably not to future conditions. They are of more than present value, however, since drought cycles will recur and similar changes will be repeated. It is in such times of stress that knowledge of exact values of production is of great importance.

LITERATURE CITED

Albertson, F. W. 1937. Ecology of mixed prairie in west central Kansas. Ecol. Monog. 7: 481-547.

Albertson, F. W., and J. E. Weaver. 1941. History of the native vegetation of western Kansas during seven years of continuous drought. Ecol. Monog. 12: 23-51.

Weaver, J. E., and F. W. Albertson. 1943. Resurvey of grasses, forbs, and underground plant parts at the end of the great drought. Ecol. Monog. 13: 63-117.

10

Germination Tests on Four Species of Sumac

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For many years studies have been made to develop a suitable tannin-producing plant in our country. A number of the sumac species have been under observation; especially *Rhus copallina* L. (black or dwarf sumac); *R. glabra* L. (white sumac); *R. typhina* Torner (staghorn sumac) and *R. aromatica* Ait. (aromatic sumac). Formerly the leaves of *R. coriaria* (Sicilian sumac) were imported to the United States in great quantities and were used in the tanning of high grade leathers. The present world conditions have curtailed the availability of this foreign sumac. With the possibility that seed of sumac would be needed in experimental plantings of domestic tannin plants, preliminary tests were made to determine a method of increasing the percentage of germination. Sumac has been used in numerous plantings along highways for beautification of the roadsides and for erosion control of steep highway banks.

According to Barkley (1937), *R. aromatica* is distributed from Nebraska and Texas eastward to the Atlantic coast. *R. glabra* is found in practically every state in the United States. *R. typhina* grows native in the north central states and eastward to the Atlantic coast. Staghorn sumac has been frequently found escaped from cultivation. *R. copallina* is distributed from New Hampshire to Georgia and west to Michigan, Missouri, and Texas. Dwarf sumac has been observed growing in a number of locations in Douglas County, Kansas. According to Gates (1940), both *R. copallina* and *R. aromatica* are found in most of the counties in eastern Kansas. *R. glabra* grows in central and eastern Kansas as well as in scattered areas of the western part of the state.

Untreated seed of the four species of sumac under observation were found to germinate very poorly, if at all, presumably because of a dormant embryo and an impermeable seed coat The following method of treatment was used. The seed was shattered from the heads by rubbing them on a 6- or 8-mesh screen. The waxy coat was rubbed off the seeds by forcing them through a 10- or 12-mesh screen depending upon the size of the seed. A fan was used to blow the chaff from the cleaned seeds. The clean seed was poured into a tub of water and the floaters were skimmed off. The water was drained off, the seeds dried and treated with concentrated sulfuric acid. A small earthen jar was used to hold the acid and a screen cylinder which would just fit inside the jar was made from 16-mesh screen and coated with a thin layer of paraffin to protect the wire. The seeds were poured into the cylinder and immersed into the acid for 20 minutes. After this treatment the acid was drained off and the cylinder of seed immediately rinsed in cold running water to remove all charred outer seed coats. Additional hollow seeds usually float off after the acid treatment. The quickest way to dry the seeds was in 16-mesh screen sieves suspended in a drying oven or in a warm room.

Seeds used in the tests were obtained locally whenever possible. Those of

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the smooth sumac were collected at numerous places in Douglas County, Kansas. Seeds of the dwarf sumac were obtained from Oklahoma and West Virginia and the staghorn sumac from Iowa.

All of the germination tests were performed in petri dishes and a germinating oven. It was found that a great amount of variation occurred in the percentage of germination of various clones of sumac. Table 1 shows the maximum germination obtained from each of the four species tested. According to Fisher et al. (1935), stratification of sumac seed for four weeks at 10° C. increased the germination by approximately 14 per cent, but tests made by this writer did not reveal any appreciable increase in germination after storage. The per cent of seeds germinating was somewhat greater for dwarf sumac than for smooth or for staghorn sumac. Aromatic sumac was not only low in per cent of germination but was also very low to germinate. Previous

TABLE 1. Maximum per cent of germination of four species of sumac seed.

Species	Untreated	Treated with Concentrated H_2SO_4
Rhus glabra	2	58
Rhus copallina	3	68
Rhus typhina	3	41
Rhus aromatica	0	22

tests upon this particular species indicate that it will be of little value as a tannin producing plant; so no further effort was made to increase the per cent of germination of its seed. Each seed sample was given 30 days to germinate.

In order to get some idea of the viability of the seed comparisons were made on the germination of one-year and two-year old seeds of *R. glabra*. The seeds which were one year old germinated 49 per cent while that of the previous year tested only 6 per cent. The seeds of both samples were treated with sulfuric acid just previous to the test.

It was thought that perhaps the proximity of the staminate clones to the pistillate clones might influence the quality of the seed produced, but tests from various selections did not reveal this to be the case. No pistillate clones could be found which were completely isolated from the male plants. Honey bees as well as many other insects aid in cross-pollination of sumac flowers.

LITERATURE CITED

BARKLEY, FRED A. A monographic study of Rhus and its immediate allies in North and Central America, including the West Indies. Annals of Missouri Botanical Garden 24:265-498. Sept. 1937.

FISHER, P. L., A. H. BRIGGS, W. A. EIKINS, E. I. ROE, C. M. ALDOUS Propagation of Game Food and Cover Plants of the Lake States. The Lake States U.S. Forest Experiment Station: 1-81, 1935.

GATES, F. C. Flora of Kansas. Department of Botany, Kansas State College, Contribution No. 391, 1940.

11

Growth and Seed Yields of Native Prairie Plants in Various Habitats of the Mixed-Prairie[1]

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INTRODUCTION

The native vegetation of the mixed prairie of west-central Kansas was subjected to the worst drought on record during the period of 1933 to 1939 inclusive. Data secured from the United States Weather Bureau reveal the fact that precipitation during this period of drought was far below normal. The rainfall deficit as reported by Albertson and Weaver (1942) was nearly 35 inches for this 7-year period. Other climatic factors such as wind movement, relative humidity, and temperature were equally abnormal.

The extreme drought period greatly modified the vegetation of the mixed prairie and the short-grass disclimax. The basal cover in these two types of vegetation before the drought ranged between 65 and 95 per cent. During the 7 years of deficient rainfall, however, this cover was reduced to nearly zero in many places and an average cover of 1 to 20 per cent was common (Weaver and Albertson, 1940). The direct causes of loss in vegetation were deficient soil moisture, overgrazing and dust carried by wind from cultivated fields and deposited upon the prairie vegetation. The reduction of plant cover resulted in large denuded areas that became extremely susceptible to wind erosion. As range depletion became more extensive the need for a sound conservation program in relation to soil erosion, range management and revegetation became evident.

The native vegetation has proved to be the best adapted to mid-west Kansas and should therefore be used for re-establishing depleted areas. These conditions have presented many problems for research men.

Some of these problems pertain to variation in growth, yield of seed and mortality rate of seedlings of native prairie plants in various habitats of the mixed prairie. These problems are of vital importance in re-establishing the vegetation in west-central Kansas. The study of basal cover of plants over a period of years will reveal the species best adapted for revegetation. The amount of seed produced by native prairie plants, as well as the ability of the seedlings to ecise, indicates to some extent their value in relation to re-establishing a native plant cover on abandoned cultivated fields and denuded rangeland.

The term seed yield often referred to in grass production is confusing. Prairie grasses often produce numerous flower stalks and the florets attain natural size, but caryopses do not develop within the florets. The use of the word "seed" for both spikelets and florets, regardless of whether or not they contain caryopses, has made data on grass seed yield difficult to interpret. The number of caryopses per hundred florets is the most accurate method of

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determining grass seed yield and is the only method of ascertaining the real value of a seed crop.

The present research is concerned with determining the yield of caryopsis-bearing seed in pounds per acre, in relation to basal cover, habitat and climatic conditions.

RELATED STUDIES

The mixed prairie was first recognized as a distinct plant association by Clements (1920) who described its nature and range, also the grouping of dominants. Albertson (1937) divided the mixed prairie near Hays, Kansas, into three types. The short grasses occupy the high level land. Little bluestem and its associates are most common on the hillsides and big bluestem domintes the lowlands and ravines.

Weaver and Albertson (1940) made a study of the deterioration of grass land that covered a large area of the midwestern plains. The research included representative grazing lands in western Kansas and Nebraska, portions of southwestern South Dakota, eastern Wyoming and Colorado, and the Panhandle of Oklahoma In many places it was difficult to distinguish denuded pasture from weedy cultivated land.

Albertson and Weaver (1942) made a thorough study of the native vegetation of western Kansas during 7 years of extreme drought. In many cases the mesic plants disappeared completely and even the most xeric species were reduced greatly in number. They grouped the results according to the conditions to which the area was subject at the time of the initial quadrating. The conditions were classified as light dusting and moderate grazing, light dusting and over-grazing, heavy dusting and moderate grazing, and heavy dusting and over-grazing.

The yield of grass seed in pounds per acre obtained from the caryopsis count affords limited reference material. Branson (1941) made an analysis of seed production of several species of native Kansas grasses by counting the caryopses per 100 florets.

Fultz (1936) made a study of grass seed on the acre basis. There was a yield of 32.5 pounds of tops which, when threshed, produced 3.4 pounds of pure seed.

Buffalo grass, growing in close association under dry land conditions such as is common in pastures throughout the western part of Kansas, normally produces but a small quantity of seed from year to year. In favorable years, however, good seed crops may be produced (Wenger, 1939-1940).

Riegel (1940) made a study of the variations in the growth of blue grama grass (*Bouteloua gracilis*) from seed produced in various sections of the Great Plains Region. The grass of the central section produced the greatest number of caryopses per hundred florets for two seasons.

Blake (1935) examined the seeds of western wheat grass (*Agropyron smithii*) and found that many of the glumes were empty. By discarding the empty glumes the per cent germination was considerably higher.

Sporobolus cryptandrus seeds which mature in the late summer or early fall are produced in enormous numbers. Ten thousand mature seeds have been obtained from a single closed panicle. Their total weight was only 0.7 gram (Weaver and Hansen, 1939).

To the investigator's knowledge, no one has determined the yield of grass

seed in pounds per acre by counting the caryopses per 100 florets, or the pounds of forb and weed seed produced per acre for the various plants of the mixed prairie.

ENVIRONMENTAL CONDITIONS

Precipitation

Data on climatic conditions were secured from the United States Weather Bureau, Hays, Kansas. The average annual precipitation for 1939 was 7.84

Table 1. Monthly and annual precipitation (P) for the years 1939, 1940, and 1941 with departure (D) from the normal. Hays, Kansas

Period	Normal	1939 P	1939 D	1940 P	1940 D	1941 P	1941 D
January	0 33	0 48	+0.15	0 72	+0 39	1 08	+0.75
February	0 82	1.05	+0.23	0.35	—0 47	0 85	+0 03
March	0 93	0.98	+0.05	0.83	—0.10	0.58	—0.36
April	2.29	1.65	—0.64	1 57	—0.72	4.61	+2 32
May	3.46	1 00	—2 46	2 41	—1.05	2 86	—0 60
June	4 10	4 71	+0 61	2 36	—1.74	6 40	+2 30
July	3.17	1.04	—2 13	4 21	+1.04	0 63	—2 54
August	3.14	3.53	+0.39	3.30	+0.16	4.14	+1 00
September	2.27	0.42	—1 85	3.14	+0.87	3.02	+0.75
October	1 35	0.18	—1.37	0.62	—0.93	2.35	+0 80
November	1.01	0.11	—0.90	2.58	+1.57	0.54	—0.47
December	0.62	0.70	+0.08	0.82	+0.20	1.07	+0.45
Total	23.69	15.85	—7 84	22.91	— .78	28.13	+4 44

inches below the recorded normal (Table 1). The fall drought, extending from August to the end of December, was the most severe on record for this time of year. Rainfall during May, July and September was 2.46, 2.13 and 1.85 inches, respectively, below normal. For June and August it barely exceeded normal.

During 1940, precipitation was approximately normal. From February to the closing days of June, the precipitation for each month was below normal, and from the beginning of July to the end of September it was above normal.

Precipitation for 1941 was 4.44 inches above normal. Rainfall during the growing season was above normal for April, June and August and only slightly below during March and May. For July, however, it was 2.54 inches below normal.

Temperature

The mean annual temperature for 1939 was 3.1° F. above normal. During the months of September and December, new high temperatures were established which were 6.5 and 6.2° F. respectively, above normal (Table 2). The mean annual temperature for 1940 was approximately normal. The two

Table 2. Average monthly and mean annual temperature (T) and departure from normal (D) at Hays, Kansas.

Period	Normal	1939 T	1939 D	1940 T	1940 D	1941 T	1941 D
January	29.8	37.0	+ 7.2	13 6	—16.2	31.3	+ 1 5
February	32.5	28.7	— 3.8	33 0	+ 0.5	32.7	+ 0.2
March	42.0	43.2	+ 1.2	44.4	+ 2.4	39 0	— 3.0
April	52.6	53.7	+ 1.1	54.0	+ 1.4	54.0	+ 1.4
May	62.0	68.6	+ 6.6	63 2	+ 1.2	66.8	+ 4.8
June	72.6	75.4	+ 2.8	74.6	+ 2 0	71.6	— 1.0
July	78.6	84.7	+ 6 1	82.4	+ 3.8	78.8	+ 0.2
August	77.4	78.0	+ 0 6	75.4	— 2.0	78.3	+ 0.9
September	68.5	75.2	+ 6.5	71.4	+ 2.7	71.6	+ 2.9
October	56.0	59.7	+ 3.7	63.1	+ 7.1	57.0	+ 1.0
November	43.5	43.0	— 0.5	38.6	— 4.9	44.2	+ 0.7
December	31.0	37.2	+ 6.2	34 5	+ 3.5	35.6	+ 4.6
Mean Annual	53.9	57.0	+ 3.1	54	+ 0.1	55.1	+ 1.2

extremes for this year were January, being 16.2° F. below normal, and October, 7.1° F. above normal. The mean annual temperature for 1941 was 1.2° F. above normal. The mean monthly temperature of May and December was 4.8 and 4.6° F., respectively, above normal. The temperature for the remaining ten months deviated but slightly from the normal.

Water Content of Soil

The amount of soil moisture available for plant growth for the three seasons determined from samples, taken to a depth of 5 feet once each month during the growing season, are shown in Table 3. The percentage of soil moisture above the hygroscopic coefficient is considered to be the amount of water available for plant growth.

In 1939, a small amount of available moisture was present in the top 12 inches in April but to only a depth of 6 inches during May and June. The moisture content was below the point of availability for the full depth of 5 feet in July but 3.5 inches of rainfall in August restored considerable available moisture in the top 6 inches.

The total rainfall of 1.6 inches in April and 2.4 in May 1940 penetrated to a depth of 12 inches and available moisture was maintained to this depth for the two months. The small amount of rainfall during June failed to supply the needs of the struggling vegetation and no vailable moisture was present to the depth of 5 feet when determinations were made at the end of the month. The precipitation during July was 4.2 inches and furnished available soil moisture for plant growth to a depth of 12 inches. Vigorous growth of vegetation during August depleted the supply of available moisture except in the top 6 inches. Continued growth in September reduced the amount of available moisture to zero.

Rainfall during the growing season of 1941 was sufficient to furnish excellent growing conditions for the drought stricken vegetation. Rainfall during April (4.6 inches) penetrated to a depth of 3 feet. The amount received during May was sufficient to maintain available moisture to the

Table 3. Percentages of available soil moisture in moderately grazed short-grass type at Hays, Kansas, for the growing seasons of 1939, 1940, and 1941.

Depth	1939						1940					
(inches)	A	M	J	J	A	S	A	M	J	J	A	S
0-6	6.2	0.5	2.9	—3.4	—4.2	—2.2	7 3	4 0	—5.3	13.3	1.5	—2.4
6-12	4.6	—0.7	—0.2	—1 8	—2.5	—2.6	1.3	0.6	—1.2	1.3	0.0	—1.4
12-24	—0.4	—1.6	—1 3	—2.2	—1.8	—1.4	—2.5	—2.1	—1.7	—1.2	—0.5	—0 9
24-36	—2.3	—1.5	—0.1	—1.3	—1.5	—0.8	—1.7	—2.3	—1 8	—1.9	—2.7	—1.4
36-48	—1.2	—1.5	—0.3	0.5	0.3	—0.1	—0.5	—0.6	—0.6	—0.4	—2.0	—1.5
48-60	—0.4	—1.1	1.8	1.3	0.5	0.3	0.9	1.4	0.0	0.6	—1.2	—0.5

Depth	1941					
(inches)	A	M	J	J	A	S
0-6	19.2	24.0	16.9	0.3	20.2	6.5
6-12	15.8	18.8	14.9	1.5	17.2	5.1
12-24	11 9	13.7	8.3	—1.5	2.1	—0.3
24-36	0.8	3.8	6 8	—1.8	—1.9	—3.5
36-48	—2 1	—0.6	4.3	—2.5	—2.9	—3.1
48-60	—2.6	0.1	2 2	—2 7	—1.4	—2.8

same depth as in April. The total of 6.4 inches in June restored available moisture to 5 feet. This amount was quickly used by the rapidly growing prairie plants and available moisture was present in only the top 12 inches when moisture determinations were made. The rainfall of 4.2 inches in

August penetrated to 24 inches and when the last soil moisture determinations were made in September, available moisture extended to 12 inches.

EXPERIMENTAL PROCEDURE

Locating the Study Areas

The three climax types of vegetation include the short grasses that grow primarily on the highland, the little bluestem on the hillsides and the big bluestem on the lowlands. In addition to these three types, are two others (revegetation and badly dusted) of considerable importance due to biotic and climatic disturbances.

Frequently, farmers, for one reason or another, have abandoned large areas of cultivated land and allowed the vegetation on these areas to seek its own course from year to year. The area considered in this study was cultivated for the last time in 1919. Successive waves of plant populations in this area resulted in a fairly stable cover of *Sporobolus cryptandrus* and *Buchloe dactyloides* in 1939.

Intense dusting in 1935 moved an enormous amount of earth from parched cultivated fields and deposited it on other fields and grass lands. The depth of layer varied greatly depending upon distance from the source of supply, topography, and nature of vegetation. When a good cover of native vegetation, or a depleted weedy one offered obstruction to the dust laden wind, a layer of dust 0.5 to 2 inches in depth was deposited over the entire area.

Dust drifts and mounds, sometimes 2 to 3 feet or more in height, were often formed (Weaver and Albertson, 1940). The dusted area considered in this study was small and bordered on three sides by cultivated fields. Before the period of drought and dust storms, the vegetation was composed of mixed grasses with big bluestem (*Andropogon furcatus*) common throughout. During the drought, however, the more xeric grasses took full possession. The death of native vegetation by intermittent dusting, particularly in 1935, resulted in successive waves of annual weeds, followed by a fairly stable cover of *Bouteloua gracilis, Buchloe dactyloides* and *Sporobolus cryptandrus.*

On June 8, 1939, a unit area of four 1-meter permanent quadrats forming a grid, was staked out for each area in the five different habitats. All quadrats were labeled with a tin plate denoting location and number of each. The ungrazed area of mixed prairie was divided into the three different types, short-grass type, little bluestem type, and big bluestem type. The variation in the little bluestem was so great, that it seemed advisable to divide it into three subdivisions—one on the upper slope, one on the mid-slope, and one on the lower slope. Data were secured on all three, only one of which, however, is reported in this paper. Quadrats on the revegetation area were located so as to include the two dominant grasses, sand dropseed (*Sporobolus cryptandrus*) and buffalo grass (*Buchloe dactyloides*). The type dusted from nearby cultivated fields was divided into badly, moderately and lightly dusted areas. Studies of the vegetation on all types were made continuously throughout the three growing seasons.

Study of Basal Cover

Each quadrat was charted with a pantograph in mid-June or early July for each year during the period of study. The planimeter was used to determine the per cent basal cover of each species of native grass found.

Studies of Seed Yield

Each year the ripened seed from all species was collected from the west half of each grid. The east half was left for other studies. The seed from each species was placed in a paper sack, that was labeled corresponding to the quadrat from which it was gathered, and stored in a dry place.

To determine the seed yield of grasses in pounds per acre for each year, the entire sample was poured out on a piece of paper. Ten 100-floret samples were then selected by taking a few from each portion of the total quantity of seed. Each sample selected was spread in a single layer on a glass plate and illuminated from below by an electric light. Empty florets were transparent, while those containing caryopses, unopened anthers or smut were opaque. All florets to contain caryopses were examined with tweezer in order to eliminate those diseased or with unopened anthers.

Each 100-floret sample was weighed after which the florets containing caryopses were separated from the empty ones. The percentage weight of caryopses in the meter quadrat was calculated. The yield in pounds per acre was calculated for each species from the gram weight of caryopsis-bearing florets in each meter quadrat.

RESULTS

The seed yield for each species in each habitat varied greatly for the different years. Variation was also apparent for each species in each habitat during each year. It was evident throughout the three years of study that the fluctuation in seed yield was governed by various environmental factors. High temperature, deficient rainfall, high wind velocity and deficient soil moisture in 1939 reduced the seed yield in many species to nil. The reduction in plant cover due to drought in the fall of 1939 also decreased the yield in 1940. Improved climatic conditions in 1941, however, produced remarkable increases in the seed yields of most of the species studied. The dense growth of *Hordeum pusillum* in the open cover of short grass decreased the light greatly and was very detrimental to the yield of native plants in these areas.

The damage to seed by insects was quite evident in 1939. Entire plants of *Morongia uncinata* and *Psoralea tenuiflora* were eaten by walking sticks. During this same season, grasshoppers destroyed many flower heads of *Bouteloua gracilis, B. curtipendula,* and *Buchloe dactyloides.* The grasshoppers also damaged large quantities of seed in 1940 and 1941. Many larvae of other insects were found feeding upon the seed of various plants when the harvest was made. While threshing *Lesquerella ovalifolia* seed in 1941, many of the pods which were devoid of seed, contained small white larvae.

The feeding of rodents was evident on Tragia ramosa as many pods were broken open and the seeds were eaten. Many burs of *Buchloe dactyloides* had been torn apart and the seed destroyed.

The combination of all environmental factors resulted in variation of seed production for each season during the period of research.

Number of Caryopses Per 100 Florets

The average number of *Bouteloua gracilis* caryopses per 100 florets in the short-grass habitat was only 1 in 1939, 12 in 1940, and 18 in 1941 (Table 4). For *Hordeum pusillum*, it was 15 in 1939, 18 in 1940, and 22 in 1941. The average buffalo grass count was 1 caryopsis per bur in 1939, 1 5 in 1940, and 2 in 1941.

In the little bluestem type, it is significant that the more xeric species averaged considerably higher than those with mesic tendencies, especially in 1939 and 1940. For example, the number in 1939 varied from an average of 3.6 caryopses per 100 florets in *Bouteloua gracilis* to 83.4 in *Sporobolus pilosus*. No caryopses were produced in either *Andropogon furcatus* or *A. scoparius*. In 1940, *Andropogon furcatus* failed to yield any caryopses, while an average of 24.1 was secured from little bluestem. The number in 1941 was uniformly high, varying from 22.3 in *Bouteloua curtipendula* to 91.3 in *Sporobolus pilosus*.

The grasses in the big bluestem type failed to produce any caryopses in 1939. In 1940 no harvest was made due to damage by livestock. In 1941, however, the count averaged 27.1 for *Bouteloua curtipendula*, the least, to 98.2 in *Sporobolus hookeri*.

Seed Yield on Different Types

Short-Grass Type

The average total seed yield of grasses, forbs and weeds was 6.6 pounds per acre in 1939, 478.9 pounds in 1940 and 326.9 pounds in 1941 (Table 5).

The grass seed yield in 1939 was only 3.6 pounds per acre from an average cover of 33.5 per cent. In 1940 the cover had decreased to 12.5 per cent from which a yield of 14.4 pounds of seed per acre was harvested. The cover and

TABLE 4. Number of caryopses per hundred florets determined from 1000 florets for the years 1939, 1940, 1941. Hays, Kansas.

Habitat	Species	Average Yield 1939	1940	1941
Short grass	Bouteloua gracilis	1	12	18
	*Buchloe dactyloides	1	1.5	2
	Hordeum pusillum	15	18	22
Little bluestem	Andropogon furcatus	0	0	25
	Andropogon scoparius	0	24.1	48.3
	Bouteloua curtipendula	4	12.1	22.3
	Bouteloua gracilis	3.6	21	33
	Bouteloua hirsuta	15.9	32.2	41.2
	Panicum virgatum	72.4	70.2	89
	Sporobolus pilosus	83.4	88	91.3
Big bluestem	Agropyron smithii	0	0	96
	Andropogon furcatus	0	0	31.2
	Bouteloua curtipendula	0	0	27.1
	Sporobolus hookeri	0	0	98.2
Revegetation	*Buchloe dactyloides	2	3	3.2
	Sporobolus cryptandrus	94	91	97
	Hordeum pusillum		20	23
Dusted	Bouteloua gracilis	4	25	38
	*Buchloe dactyloides	1.6	2.2	2.8
	Hordeum pusillum	18	23	17

*Number of caryopses per bur determined on basis of 100 burs.

yield were further increased to 29.3 per cent and 30.4 pounds per acre respectively in 1941. It is significant that the lowest yield occurred in 1939 when the cover was greatest. This is doubtless due to the extended drought in 1939 during which very few of the florets produced caryopses.

The forb population in the short grass type was extremely sparse. From an average of 1.5 *Malvastrum coccineum* plants in two square meters no seed was produced in 1939. In 1940, however, an average of three plants, of three different species, yielded a total of 58 pounds per acre. In 1941 the same plants produced 79 pounds per acre.

The weed population was also very sparse in 1939. Only an average of 10 plants of *Hordeum pusillum* yielding 3 pounds per acre of seed were found in 2 square meters of short grass. In 1940 the number, represented by six species,

was increased to 300 and the yield of seed to 406.5 pounds per acre. These yields indicate great fluctuations in seed yield of annual weeds from year to year. For example in 1939 only one species (*Hordeum pusillum*) was present. In 1940, however, seven species were found, most of which were pepper grass

TABLE 5. Per cent basal cover of grass, average number of forbs and weeds in two 1-meter quadrats, and average yield of seed in pounds per acre of grasses, forbs and weeds in the short-grass type. Hays, Kansas.*

	1939		1940		1941	
Species of grass	Cover	Yield	Cover	Yield	Cover	Yield
Buchloe dactyloides	2.6	2.1	2.7	3.2	9.9	6.7
Bouteloua gracilis	30.4	1.5	9.7	11.2	19.2	23.8
Sporobolus cryptandrus	0.5	0.0	0.1	0.0	0.2	0.0
Total—grasses	33.5	3.6	12.5	14.4	29.3	30.4
Species of forbs	Number	Yield	Number	Yield	Number	Yield
Allium nuttallii	0.0	0.0	0.5	50.0	0.5	70.0
Malvastrum coccineum	1.5	0.0	1.5	0.0	1.5	0.0
Psoralea tenuiflora	0.0	0.0	1.0	8.0	1.0	9.0
Total—forbs	1.5	0.0	3.0	58.0	3.0	79.0
Species of weeds	Number	Yield	Number	Yield	Number	Yield
Chenopodium album	0.0	0.0	3.5	14.0	0.0	0.0
Festuca octoflora	0.0	0.0	0.0	0.0	14.0	9.0
Hordeum pusillum	10.0	3.0	8.0	3.0	510.0	200.0
Lappula occidentalis	0.0	0.0	41.5	40.0	0.0	0.0
Lepidium densiflorum	0.0	0.0	217.5	333.0	0.0	0.0
Plantago purshii	0.0	0.0	18.0	9.0	7.5	5.5
Plantago spinulosa	0.0	0.0	0.0	0.0	4.0	5.0
Salsola pestifer	0.0	0.0	11.0	5.0	0.0	0.0
Solanum rostratum	0.0	0.0	0.5	2.5	0.0	0.0
Total—weeds	10.0	3.0	300.0	406.5	535.5	217.5
Total seed yield of all plants		6.6		478.9		326.9

*Figures for grass seed yield represent the yield in pounds per acre of caryopsis-bearing florets.

(*Lepidium densiflorum*) and stick tights (*Lappula occidentalis*). In 1941 the two previously mentioned species of weeds were completely absent and were replaced primarily by the two weedy grasses, *Hordeum pusillum* and *Festuca octoflora*. The yield from the 510 plants of *Hordeum pusillum* was 200 pounds per acre and from the 14 plants of *Festuca octoflora* was 9 pounds per acre.

Little-bluestem Type

Much greater diversity in abundance and composition was found in this habitat than in the short-grass type. For this reason study areas were located in three positions—one on the upper slope, one near the middle and one on the lower slope. Data secured from the area on the lower slope are nearly average for all three locations and are therefore given in table 6.

The total seed yield for grasses and forbs (no weeds were found here) was 40.6 pounds per acre in 1939. The yield was increased to 76.3 pounds in 1940 and to 360 pounds in 1941.

The total cover of grass in 1939 was only 21 per cent from which a yield of 11.6 pounds per acre was harvested. The cover in 1940 was reduced to 7.5 per cent and the seed yield to only 7.3 pounds per acre. The cover in 1941 had been restored to approximately the 1939 amount but favorable growing conditions were responsible for a greatly increased yield of 53 pounds of seed per acre. It should be noted that little bluestem, the dominant in this type under normal conditions, lost cover during the fall drought of 1939 and failed to produce any caryopsis-bearing seed in either 1939 or 1940. Side oats grama, the grass that generally replaced the little bluestem, produced seed, though in decreased amounts, throughout the period of study. Blue grama, seldom found except in small amounts in this type, maintained a fairly con-

stant cover and produced some seed during all three years. The cover and yield of lesser important grasses are given in table 6.

The forbs in this habitat showed fully as much variation in number and yield as did the grasses. The yield in 1939 was 29 pounds per acre from an average total of 35 forb plants in two quadrats. In 1940 the number of forb plants was increased to 48 and the seed yield to 69 pounds per acre. The increase in abundance of plants in 1941 over the two previous years was not significant but from the average number of 54 plants the yield of 307 pounds per acre was increased nearly 450 per cent over that of the previous year.

TABLE 6. Per cent basal cover of grass and average number of forbs in two 1-meter quadrats, and average yield of seed in pounds per acre of grasses and forbs in the little-bluestem type. Hays, Kansas.

	1939		1940		1941	
Species of grass	Cover	Yield	Cover	Yield	Cover	Yield
Andropogon furcatus	3.9	0.0	1.6	0.0	5.1	13.3
Andropogon scoparius	1.7	0.0	0.1	0.0	0.8	1.0
Aristida longiseta	0.5	0.2	0.2	0.1	0.4	0.3
Bouteloua curtipendula	6.9	2.2	2.5	1.1	5.8	13.2
Bouteloua gracilis	1.8	1.1	1.2	1.8	3.8	4.1
Bouteloua hirsuta	2.8	1.0	0.4	0.3	2.4	6.8
Panicum virgatum	1.4	3.5	0.7	2.0	2.2	6.1
Sporobolus cryptandrus	0.1	0.0	0.0	0.0	0.0	0.0
Sporobolus pilosus	1.9	3.6	0.8	2.0	1.4	8.2
Total—grasses	21.0	11.6	7.5	7.3	21.9	53.0
Species of forbs	Number	Yield	Number	Yield	Number	Yield
Cheirinia aspera	4.0	13.0	0.0	0.0	3.0	30.0
Aster multiflorus	6.0	0.0	12.0	21.0	17.5	180.0
Cirsium undulatum	0.0	0.0	1.0	0.0	1.0	4.0
Echinacea angustifolia	4.0	12.0	3.0	13.0	1.0	4.0
Galpinsia lavendulaefolia	0.5	0.0	0.0	0.0	0.0	0.0
Houstonia angustifolia	0.0	0.0	0.0	0.0	0.5	2.0
Liatris punctata	0.5	0.0	2.0	10.0	1.0	9.0
Morongia uncinata	5.0	0.0	5.0	7.0	4.0	8.0
Meriolix serrulata	1.5	2.0	1.0	0.0	0.5	5.0
Psoralea tenuiflora	3.0	0.0	10.5	0.0	7.5	5.0
Thelesperma gracile	0.5	0.0	1.5	8.0	6.0	45.0
Tragia ramosa	9.5	0.0	12.0	10.0	11.5	15.0
Scutellaria resinosa	0.5	2.0	0.0	0.0	0.5	0.0
Total forbs	35.0	29.0	48.0	69.0	54.0	307.0
Total seed yield of all plants		40.6		76.3		360.0

Only one species (*Echinacea angustifolia*) produced seed during all three years. The western wall flower (*Cheirinia aspera*) was present in 1939 and 1941 but failed to appear in 1940. This is quite in harmony with this biennial forb. The yield of such plants as the sensitive briar (*Morongia uncinata*), wild alfalfa (*Psoralea tenuiflora*) and rayless thelesperma (*Thelesperma gracile*) was doubtless affected by various insects common to the prairie.

Big-bluestem Type

No forbs or weeds were present in the study area for this habitat though both types of plants are frequently found. No attempt was made to chart the basal area of the grasses in this habitat but rather the number of grass stems per square meter.

In 1939, an average total of 853 stems were present in each meter quadrat (Table 7). Big bluestem (*Andropogon furcatus*) furnished about 460 stems and dropseed (*Sporobolus hookeri*) about 370 stems. Western wheat grass (*Agropyron smithii*) and side oats grama (*Bouteloua curtipendula*) furnished nearly all the remaining stems. None of these grasses produced clums higher than 16 inches on which practically no flower heads developed.

The number of stems in 1940 was slightly less than in 1939. Some seed was

produced in surrounding locations but none was harvested in this area because of destruction by livestock.

The average total yield in 1941 was 1069.2 pounds per acre. All species regardless of abundance produced some seed. It is significant, however, that 491 stems of big bluestem produced at the rate of only 50.5 pounds per acre while *Sporobolus hookeri,* the next most abundant species, yielded 909.3 pounds per acre. Even the average of 19.5 stems of western wheat produced 20 pounds per acre more than did big bluestem. Side oats grama and *Carex gravida* yielded 12.5 and 26.4 pounds per acre respectively. The large seed yield of *Sporobolus hookeri* probably explains its rapid spread in ravines during the drought period.

TABLE 7. Average number of stems per square meter and pounds of seed per acre of each species of grass in 2 quadrats of big bluestem type. Hays, Kansas.

Species	1939 No. Stems	1939 Yield	1940 No. Stems	1940 Yield	1941 No. Stems	1941 Yield
Andropogon furcatus	461.6	0.0	360.5	0.0	491.0	50.5
Agropyron smithii	17.	0.0	13.	0.0	19 5	70.5
Bouteloua curtipendula	4.	0.0	2.5	0 0	6.5	12.5
Carex gravida	1.	0.0	0.0	0.0	4	26.4
Sporobolus hookeri	369 5	0.0	391.	0.0	432	909 3
Total	853 0	0.0	767.0	0.0	953.0	1069.2

Revegetation Type

The cover in the buffalo grass area in 1939 was 79.0 per cent nearly all of which was buffalo grass (Table 8). This was reduced to only 52.5 per cent in 1940 but the favorable growing conditions in 1941 restored the cover to 89.5 per cent. The yield of caryopsis-bearing florets was 31.2 pounds per acre in 1939, 30.6 pounds in 1940 and 82.6 pounds in 1941.

The ragweed (*Ambrosia psilostachya*) was the only forb of any importance in this area and it failed to appear until in 1941 when an average of 18 plants in two quadrats yielded at the rate of about 100 pounds of seed per acre. No weeds were present in 1939 but an average of 135 plants of *Hordeum pusillum* were present in 1940 with a yield of 30 pounds of seed per acre. The number of plants was increased to 450 per unit area in 1941 and the yield to 100 pounds of seed per acre.

Sand dropseed (*Sporobolus cryptandrus*) dominated the areas not occupied by buffalo grass. The average cover of this species was 24.8 per cent in 1939, 16.5 in 1940 and 17.5 in 1941 The yield in the same order during these three

TABLE 8. Per cent basal cover of grass and average number of forbs and weeds on two 1-meter quadrats in two areas on a revegetation type, and pounds of seed per acre. Hays, Kansas.

Species	1939		1940		1941	
Buffalo grass area	Cover	Yield	Cover	Yield	Cover	Yield
Aristida longiseta	0.4	0.0	0.3	0.0	0.4	0.0
Buchloe dactyloides	78.6	31.2	52.2	30.6	89.5	82.6
Forbs	Number	Yield	Number	Yield	Number	Yield
Ambrosia psilostachya	0.0	0.0	0.0	0 0	18.0	100.0
Weeds						
Hordeum pussillum	0.0	0.0	135.0	30.0	450.0	100 0
Sporobolus cryptandrus area	Cover	Yield	Cover	Yield	Cover	Yield
Grasses						
Aristida longiseta	0.2	0.0	0.3	0.0	0.5	0.0
Sporobolus cryptandrus	24 8	172.0	16.5	87 0	17.5	163.0
Forbs	Number	Yield	Number	Yield	Number	Yield
Ambrosia psilostachya	0.0	0.0	0.0	0.0	1.0	15.0
Weeds						
Hordeum pusillum	100.0	12.0	125.0	18 0	260 0	250 0

years was 172, 87 and 163 pounds per acre respectively. No forbs of any importance were present in this area. *Hordeum pusillum* was represented by an average of 100 per two meters in 1939 and a yield of only 12 pounds of seed per acre. In 1940 the average was increased to 125 and the seed yield to 18 pounds per acre. An average of 260 plants per unit area were present in 1941. They yielded at the rate of 250 pounds of seed per acre.

Badly Dusted Type

The average total seed yield of grasses and weeds was 89.9 pounds per acre in 1939, 116.3 pounds in 1940 and 168.8 pounds in 1941 (Table 9).

TABLE 9. Per cent basal cover of grass and average number of forbs in two 1-meter quadrats, and average yield of seed in pounds per acre in a badly dusted short-grass area. Hays, Kansas.

	1939		1940		1941	
Species of grass	Cover	Yield	Cover	Yield	Cover	Yield
Bouteloua gracilis	8.6	0.0	6.1	8 5	20 1	51 0
Sporobolus cryptandrus	0.1	0 0	0.3	0.0	1.7	0 0
Total	8.7	0.0	6.4	8 5	21 8	51.0
Species of weeds	Number	Yield	Number	Yield	Number	Yield
Chenopodium album	40.0	9.9	304.0	91 0	0 0	0.0
Hordeum pusillum	0.0	0.0	2.5	1.0	114.0	99.0
Lappula occidentalis	22.5	80 0	2.0	8.8	0.0	0.0
Lepidium densiflorum	0.0	0.0	2.5	5.0	0.0	0.0
Mollugo verticillata	0.0	0.0	0.0	0.0	112.5	0.0
Panicum capillare	0.0	0.0	0.0	0.0	30.0	18.8
Sophia pinnata	0.0	0 0	2.0	2.0	0.0	0.0
Total	62.5	89 9	313.0	107 8	256 5	117.8
Total seed yield of all plants		89.9		116.3		168.8

The grass seed yield in 1939 was nil from an average cover 8.7 per cent. In 1940 the cover had decreased to 6.4 from which a yield of 8.5 pounds of seed per acre was harvested The cover and yield were further increased to 21.8 per cent and 51.0 pounds per acre respectively in 1941.

The total number of weeds per unit area in 1939 was 62.5, which produced at the rate of 89.9 pounds of seed per acre. In 1940, an average of 313.0 plants yielded 107.8 pounds of seed per acre and in 1941 an average of 256.5 plants yielded 117.8 pounds of seed.

SUMMARY

The purpose of this study was to determine variations in growth and seed yield of native prairie plants in various habitats of the mixed prairie, during the seasons of 1939, 1940, and 1941.

The study was made during three years that were extremely variable in climatic conditions. Precipitation during 1939 was 7.84 inches below normal. In 1940 it was approximately normal, and in 1941 it was 4.44 inches above normal.

The mean annual temperature for 1939 was 3.1 degrees F. above normal, in 1940, approximately normal, and in 1941, only 1.2° F. above normal.

Water content of soil correlated closely with precipitation. During the summer and fall of 1939 no soil moisture was available for plant growth in the upper 3 feet of soil. In 1940 soil moisture was available in only the upper 2 feet of soil, except July and August when it was more available to plant growth in the upper 6 inches. In 1941 it was available to plant growth in the upper 3 feet of soil every month, except July, when it was non-available to plant growth in the upper 12 inches of soil.

All types of vegetation suffered greatly during the fall drought of 1939. The

more xeric species, however, suffered least. During the wet season of 1941 most species more than regained their loss of the previous two years.

On the short-grass type *Buchloe dactyloides* suffered more reduction in basal cover from the 1939 drought than did *Bouteloua gracillis.* When moisture was present in 1941, however, *Buchloe dactyloides* increased far more rapidly than did *Bouteloua gracilis*

Of the forbs on the short-grass type, *Malvastrum coccineum* increased in number during the 1939 drought. *Psoralea tenuiflora* held its own fairly well.

Bouteloua curtipendula suffered less from drought than any species of grass on the little-bluestem type. *Andropogon scoparius* suffered the greatest loss.

During the wet season of 1941, *Andropogon furcatus* made a greater increase in cover than did the other species on the little-bluestem type.

In the big-bluestem type, *Sporobolus hookeri* increased in number of stems per unit area each season during the period of study. All other species suffered a loss during the dry season of 1939.

Buchloe dactyloides suffered a greater loss of basal cover than did *Bouteloua gracilis* on the dusted type It also increased more rapidly during the wet spring of 1941.

Sporobolus cryptandus showed an average caryopses count of 94 per hundred florets during the period of study. This was the highest of all species.

Bouteloua hirsuta produced an average of 30 caryopses per hundred florets, the highest average for the more important short grasses.

Sporobolus cryptandrus was the only species of grass that gave a high seed yield during the dry summer of 1939. Most of the other species yielded a small amount and many none at all.

The only forbs that produced any amount of seed in 1939 were *Cheirinia aspera, Echinacea angustifolia* and *Meriolix serrulata.* During the wet season of 1941, most all species produced a considerable amount of seed.

Hordeum pussillum yielded the most seed of all ruderals. In 1941 it produced 771 pounds of seed per acre. In one case a meter quadrat produced 9000 stems.

This study indicates that growth and seed yield correlated very clsely with the amount of available soil moisture during the season growth.

LITERATURE CITED

1. ALBERTSON, F. W. 1937. Eclogy of the mixed prairie in west central Kansas. Ecol. Monog., 7: 481-547.
2. ALBERTSON, F. W. and WEAVER, J. E. 1942. History of the native vegetation of western Kansas during seven years of continuous drought. Ecol Monog., 12: 23-51.
3. BLAKE, A. K. 1935. Viability and germination of seeds and early history of prairie plants. Ecol. Monog., 5: 405-460.
4. BRANSON, LESTER R. 1941. An analysis of seed production of native Kansas grasses during the drought of 1939. Trans. Kan. Acad. Scie., 44: 116-125.
5 CLEMENTS, F. E. 1920 *Plant indicators,* Carnegie Inst., Washington.
6. FULTZ, JESS L. 1936. Blue grama grass for erosion control and range reseeding in the great plains and a method of obtaining seed in large lots. U. S. Dept. of Agr., Cir. No. 402.
7. GATES, F. C. 1941. *Weeds in Kansas.* Topeka, State Printing Office, 1941, 360p.
8 ———. *Wild flwers in Kansas.* Topeka, State Printing Office.
9. HITCHCOCK, A. S. 1935. Manual of the grasses of the United States. U. S. Dept. Agr. Mis. Pub., No. 200.

10. NORRIS, ELVA. 1939. Ecological study of the weed population of eastern Nebraska. Nebraska University Press. (University Studies, vol. 39, No. 2, June, 1939, pp. 28-90).
11. RIEGEL, D. A. 1940. A study of the variations in the growth of blue grama grass from seed produced in various sections of the great plains region Trans. Kan. Acad. Sci., 43: 16-84.
12. RYDBERG, P. A. 1932. *Flora of the prairies and plains of Central North America.* Lancaster Press, Inc.
13. SAVAGE, D. A. 1937. Drought survival of native grass species in the central and southern great plains, 1935. U. S. Dept. of Agr. Tech. Bul., No. 549.
14. WEAVER, J. E. and ALBERTSON, F. W. 1940. Deterioration of grassland from stability to denudation with decrease in soil moisture. Bot. Gaz. 101: (3) 598-624.
15. WEAVER, J. E. and ALBERTSON, F. W. 1940. Deterioration of midwestern ranges. Ecology 21: (2) 216-236.
16. WEAVER, J. E. and HANSEN, WALTER W. 1939. Increase of *Sporobolus cryptandrus* in pastures of eastern Nebraska Ecology 20: 374-381.
17. WENGER, LEON E. Improvement of buffalo grass in Kansas. Kans. State Bd. of Ag., 1939-1940, pp. 211-224.

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With the resumption of normal conditions of rainfall, the vegetation as a whole was normal and the variations, curiosities, and abnormalities which have made up so many of these notes in the past were not in evidence. Furthermore, with the increased attention given to war efforts, botanical activity was much diminished during the year.

The year as a whole was characterized by temperatures approximately normal and precipitation persistently above normal, the results of which were a great vegetative growth of many plants. The same thing was true of weeds in general, especially the taller ones, whereas groundweeds, such as *Tribulus terrestris,* were early shaded out. In areas where they dominated a few years ago, few or no plants of Tribulus were found this year.

One fasciation, information on which was not available for a previous botanical note, was brought to my attention by D. R. Cornelius. The plant was *Lespedeza virginica* (L.) Britton which he found fasciated in Montgomery County in 1941.

Not only did *Cornus mas* fruit excessively for the first time in many years but the fruits were so numerous and large that a few quarts were put up as preserves.

During the year comparatively few additions were made to the Kansas State herbarium; the most important included collections during 1941 and 1942 from Gove County by Clement Weber. This collection added 125 species to the state Gove County collections. Bernard Rohrer sent in about a dozen additions to Miami County and Duncan Gwartney a few from Labette County, C. J. Swedlund from Wallace County, Clyde Merritt from Crawford and Cherokee Counties, and W. L. Morris and John Hancin from Saline County.

R. H. Smith, county weed supervisor of Kearny County, sent in a very nice specimen of *Eragrostis cilianensis* from Lakin in September. This specimen is of particular interest because it completed the state county collections for a second plant and the first grass. Now, two of the perhaps 30 or 40 species which surely grow in every county of the state are represented in the state herbarium by specimens from each of the 105 counties. They are *Solanum rostratum* and *Eragrostis ciliansis.*

One plant, *Centunculus minimus,* new to the state was collected in Saline County by John Hancin.

Xanthium spinosum, a southern weed, appeared in Harvey County where it was collected by H. B. Harper in August, 1942.

In the Kansas orchid collection, whose identifications were checked over this year by Donovan S. Correll, one specimen turned out to be *Spiranthes lucida* (H. H. Eaton) Ames. This was collected in 1930 in Cloud County, Kansas, by S. V. Fraser. Mr. Correll considered this an especially noteworthy exten-

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[1]Contribution No. 446 from the Department of Botany and Plant Pathology, Kansas State College of Agriculture and Applied Science.

sion of range of orchids. Mr. Correll, together with Prof. Ames, is writing up the orchid flora of the United States and Canada.

In addition, the following persons sent in one to three or four specimens which were added to the state herbarium: John Q. Adams, Wm. K. Babel, Wm. L. Barnhill, Leo Bennett, W. L. Collins, H. L. Cox, G. L. Dimmitt, Mrs. W. J. Douglass, F. F. Farwell, R. B. Flanders, Leon F. Fouse, Joe M. Goodwin, P. B. Gwin, C. A. Hageman, P. W. Holm, C. O. Johnston, J. V. Kelly, Mrs. C. Kraemer, Alvin E. Lowe, Clyde Miller, H. W. Neiswanger, John P. Perrier, Alba M. Soukup, Anna Steller, H. J. Stewart, Mary Joanne Weirauck, Ruth E. Weirauck, Mrs. J. B. Wright, T. F. Yost, and E. B. Zohn.

During the spring almost all of the available duplicates were sent out in exchange to various herbaria in different parts of the United States. From the exchange we have received noteworthy additions to our collection of poisonous plants.

13

A Source Study of Blue Grama Grass and the Effect of Different Treatments on Establishing Stands of Grass Under Field Conditions at Hays, Kansas

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INTRODUCTION

This study was undertaken to obtain further data on establishing seedlings of blue grama grass (*Bouteloua gracilis*) under field conditions when grown from seed secured at various locations in the Great Plains Region. Each source was subjected to different treatments of soil preparation and clipping to provide further information regarding its weed tolerance and response to grazing.

Acknowledgment and appreciation is extended to Donald R. Cornelius and the Soil Conservation Service, and to D. A. Savage for furnishing the blue grama seed from the various sources.

RELATED STUDIES

Riegel (1) made a study of the variations in growth of blue grama grass when grown from seed secured from different sources in the Great Plains Region with certain environmental factors such as weed competition and moisture deficiency controlled. Hopkins (2) made a similar study of side-oats grama (*Bouteloua curtipendula*). Hase (3) studied the effects of clipping and weed competition on the spread of native grass seedlings (blue grama being included) but he made no attempt to study source variations.

EXPERIMENTAL PROCEDURE

The area selected was a silty, clay-loam upland soil with a slope of about 1 per cent. Sudan grass had been grown on the ground the year before and a fair mulch was present. The general plot was laid out 10 rods long and 6 rods wide, the length of the plot being east and west. Each tier of plots running north and south was planted with seed from a single source. The seed from each source was planted in 6 plots, each of which received a different treatment, as follows:

Plot No. 1 on the north was cultivated before planting and beginning July 1 was closely clipped with a lawn mower each two weeks to simulate grazing (Fig. 1).

Plot No. 2 was not cultivated before planting and was clipped the same as No. 1.

Plot No. 3 was not cultivated before planting but weeds were clipped with a mowing machine twice during the season. (Fig. 2).

Plot No. 4 was cultivated before planting and weeds were clipped as in No. 3.

Plot No. 5 was cultivated before planting but no clipping treatment was given (Fig. 3).

Plot No. 6 was neither cultivated nor clipped.

Using this system of treatments each source had six plots each receiving a different treatment of cultivation or clipping. The seed of each source was

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broadcast at the rate of approximately 16 pounds per acre of good field run seed. After planting, all seedings were double packed with a packer.

GERMINATION AND GROWTH OF SEEDLINGS. Seed was planted June 2 (Table I). On June 16 observations showed a good stand in most plots. Grasshopper nymphs were thick in the uncultivated areas and were eating many of the seedling plants. Poison was scattered on the project June 18 but it did not control the grasshopper damage. On June 30 good to excellent stands were present on most of the cultivated areas, while the plots which we unclipped and not cultivated generally had poor stands of seedlings. Little grasshopper damage was noted after this date as the plants had 3 or more leaves and apparently were no longer palatable to the insects.

TABLE I. Caryopsis count and germination tests and amount of seed sown for the various sources.

Source	Year harvested	Caryopses per 100 florets	Germination test in % seeds germinating	Seed per 16 sq. rods
Lovington, N. Mexico	1937	45	87	16 oz.
Maxwell, N. Mexico	1940	46	88	16 oz.
Tucumcari, N. Mexico		12	90	30 oz.
Dumas, Texas	1939	19	32	20 oz.
Hereford, Texas	1938	35	75	24 oz.
Marquette, Kansas	1939	48	88	16 oz.
Holt Co., Nebraska		Processed	90	10 oz.
North Platte, Nebraska	1939	46	98	16 oz.
Killdeer, N. Dakota	1938	50	62.3	16 oz.
Mandan, North Dakota	1939	8	60	30 oz.

On July 28 bisects were dug in the grazed-cultivated plots to determine root penetration. The roots of the North Platte, Nebraska, source had penetrated to a depth of 42 inches, those from Killdeer and Mandan, North Dakota, to about 24 inches and the remainder to about 36 inches. A check bisect was dug in the uncultivated and unclipped treatment of the Lovington, New Mexico, source The roots had penetrated only 20 inches as compared to 36 inches in the grazed and cultivated treatment (Table II).

The average number of tillers which the plants of the various sources had produced by July 28 were about the same. The plants from the Hereford, Texas, source, had the least with 6, while the other sources average from 9 to 12 in the grazed and cultivated treatment.

No seedlings were found from the Hereford, Texas, source in the unclipped-uncultivated treatment. It was apparently very susceptible to grasshopper damage. The other sources ranged from 1.5 tillers per plant for Marquette, Kansas, to 3 for Lovington, New Mexico, the average being about 2 tillers per plant in this treatment. Severe shading, weed competition, and grasshopper damage contributed to the poor development of the seedlings.

The southern sources were the tallest on July 28, averaging about 5.5 inches, while the North Dakota sources were only 2 inches in height.

WEED COMPETITION. Weeds grew vigorously during the spring and summer. They were much less numerous in the cultivated areas than in those uncultivated. On July 1 the weeds in both the cultivated and uncultivated areas of the grazed treatment were closely clipped. The blue grama seedlings were more numerous and were somewhat larger in the cultivated plots. Shading and grasshopper damage in the weedy, uncultivated area were responsible for the difference in seedling growth. Close clipping with the lawn mower each

LIST OF FIGURES

Fig.

1. A view of the plots of blue grama grass which were closely clipped each two weeks to simulate heavy grazing. The area to the right of the stake was not cultivated and has a thinner cover of grass than the one which was cultivated.
2. This view shows the plots on which the weeds were clipped with a mowing machine twice during the season. The area to the right was cultivated before seeding and has a heavier cover of grass than the area to the left of the picture which was not cultivated before seeding. The weeds were more numerous on the uncultivated area.
3. This is a view of the plots on which the weeds were not clipped during the season The area to the left was cultivated to kill the weeds before sowing the grass seed while the plots to right of the stake were shown without cultivating the seed bed before planting. It is evident the weeds are larger and more numerous on area to right.


1
2
3

TABLE II Root penetration, tiller development, and height of various sources on July 28, 1941.

Source	Depth of roots grazed and cultivated	Tillers per plant grazed and cultivated	Height of plants grazed and cultivated
Lovington, New Mexico	36″	10	5″
Maxwell, New Mexico	....	12	6″
Tucumcari, N Mexico	....	10	5.5″
Dumas, Texas	....	8	4″
Hereford, Texas	35″	6	3″
Marquette, Kansas	36″	10	4″
Holt Co., Nebraska	33″	11	3″
North Platte, Nebraska	42″	9	4″
Killdeer, North Dakota	22″	11	2″
Mandan, North Dakota	24″	9	2″

two weeks eliminated a large amount of the weed competition from all the plots in the grazed treatment from July 1 until the end of the growing season.

In the clipped treatment the weeds were also more numerous in the plots which were uncultivated before seeding. Russian thistles (*Salsola pestifer*), green fox tail *(Setaria viridis)*, and stink grass *(Eragrostis cilianensis)*, were the most prominent weeds. The weeds were quite large on July 19 when they were clipped with a mowing machine on both the cultivated and uncultivated areas. This left considerable debris on the ground and shaded out some seedlings of blue grama. This treatment was clipped again on August 17, after which only a limited growth of green fox tail and stink grass occurred during the remainder of the growing season.

The weeds were scattered in the cultivated part of the unclipped treatment but the Russian thistles were large and occupied considerable space, causing the seedlings to be badly shaded and stunted. Some sunflowers and weedy grasses were present and mat spurges (*Chamaesyce sp.*) were plentiful. On the whole the grass seedlings were numerous and vigorous. The uncultivated section of the unclipped treatment presented a different condition. Twelve different species of weeds were noted in the area, sunflowers and Russian thistles being the most plentiful. The seedlings of blue grama were few and small, due to shading and to competition for moisture by the large weeds.

All sources were affected in a similar manner by the weeds. Where they were numerous the grass seedlings were reduced in size and abundance but where the weeds were scarce the grass seedlings were abundant and vigorous.

DATE OF FLOWERING AND HEIGHT OF FLOWER STALKS OF VARIOUS SOURCES. The data for time of flowering and height of flower stalks were secured from the plots which had been cultivated before planting but had not been clipped. On July 20, seven weeks after planting, the sources from North Dakota began to blossom. They were followed by Maxwell, New Mexico, and the Kansas and the Nebraska sources. All sources were in flower when observations were made on August 23.

The southern plants from New Mexico were tallest, averaging about 16 inches in height. The Texas sources were about 12 inches tall, while the central sources (Kansas and Nebraska) averaged about 14 inches in height. The plants from sources in North Dakota attained an average height of 8 inches, one half that of the New Mexico sources.

PER CENT OF GROUND COVER. Meter square quadrats were staked out in each of the six treatments for three sources, Maxwell, New Mexico, representing the southern section of the Great Plains, Marquette, Kansas, representing

the central states of the region, and Killdeer, North Dakota, from the Northern Plains states. The per cent of cover was obtained only on the cultivated-grazed treatment of the other sources.

The quadrats were pantographed October 23, and the percentage of cover computed with the planimeter. The data secured (Table III) on the ground covers of the three representative sources is significant. Under the treatments where the seed bed was prepared by cultivation before seeding, and followed by clipping of weeds, the cover on the southern and central sources was about twice that of the northern source. Where the ground was not tilled before planting and followed by clipping. the cover of the northern source greatly exceeded that of the central source. The southern source was not affected where clipping began soon after the plants emerged but where weeds were allowed to grow for some time before clipping, the cover at the end of the season was only about one-half that of the plots where the seed bed was prepared by tillage.

TABLE III. Per cent basal cover of plants from the various sources under different treatments at the end of first season of growth.

	Cultivated* and grazed	Uncultivated and grazed	Uncultivated and weeds clipped	Cultivated and weeds clipped	Cultivated and weeds unclipped	Uncultivated and weeds unclipped
Maxwell, N M.	31.4	34.8	17.6	31 0		2 6
Marquette, Kan.....	25.8	7.9	10.2	30.3	26.5	1.4
Killdeer, N. M	14.9	22.2	21.0	15.0	17.6	2.6
Lovington, N. M..	38.1					
Tucumcari, N. M...	25.5					
Dumas, Texas	18.7					
Hereford, Texas....	2.1					
Holt Co., Neb.	18.7					
North Platte, Neb.	19.9					
Mandan, N. D.	5.4					

*Cultivated refers to the cultivation of the ground before seeding.

The number of seedlings was greatly reduced in the plots where planting in an untilled seed bed was followed by no clipping of the weeds. Only a few small stunted plants survived but again the northern source was equal to the southern and exceeded the central source, having a ground cover of 2.6 per cent compared to 1.4 per cent for the central source.

The frequent clipping of the seedlings apparently did not reduce the ground cover of any source in the plot where the ground had been cultivated to kill the weed growth before planting. Frequent clipping apparently did not reduce vitality for the cover increased as rapidly the second season as that of any of the other treatments when the care of the plots was discontinued.

DISCUSSION

Very favorable moisture conditions existed during the season of study. Near the experimental plot, in a field planting of blue grama from a southern source, the roots of the grass were found to have penetrated 6 feet into the soil. Although the roots were not examined in the experimental plots, a similar condition no doubt existed in the plots which had the weeds removed by clipping.

Soil moisture determinations showed that the plots, where cultivation preceded planting, consistently had more available moisture in the subsoil than those where the seed was planted in untilled soil. The competition offered by weeds and the tightness of the soil were factors which helped to cause such a condition. There was much more forage on the plots which were clipped with

the mowing machine and on the unclipped plots which were tilled before planting than was present on the plots where the foliage was removed with a lawn mower. In many of the first mentioned plots, field mice were able to make their runways under the heavy growth of forage.

The data which have been compiled must not be construed to be conclusive as it is local in scope and represents only growth response to the environmental factors encountered in one season. Certain trends, however, are apparent.

SUMMARY

The study was conducted to obtain data on source plantings of blue grama and seedling establishment under different treatments of seed bed preparation and clipping.

Seed from 10 sources in the Great Plains region was planted and subjected to 6 different experimental treatments involving weed competition and grazing or clipping.

The seed was sown at the rate of about 16 pounds of good commercial seed per acre and was broadcast and double packed on June 2, 1941.

Most of seedlings had emerged within 2 weeks and many which were in the weedy plots were eaten by hoppers. The Hereford, Texas, source apparently suffered the greatest damage and the Northern sources, Killdeer and Mandan, North Dakota, the least. After the seedlings had produced 3 or more leaves they ceased to be eaten to any extent by the grasshoppers

Excellent stands were usually obtained where cultivating before planting killed the weeds and destroyed the shelter of grasshopper nymphs Where no seed bed preparation was made the stands of grass seedlings in most of the plots was sparce, due to grasshopper competition and shading.

On August 1 grass roots from most seed sources had penetrated to a depth of 3 feet where the seed bed had been cultivated and frequent clipping had removed the weeds. The northern sources, however, had penetrated the soil only to about 2 feet under similar treatment. Root systems were restricted to 2 feet or less in length in the unclipped plots of the southern and central sources upon which the weeds had not been killed before planting the seed.

The number of tillers per plant on August 1 was most numerous on plots where the seed bed had been tilled before planting and least for all sources where neither clipping of weeds nor seed bed preparation was practiced. On the above date the leaves of the grass plants of the southern sources were about 5.5 inches in length while those of the northern sources were only 2 inches in length.

Weeds were consistently more numerous on the plots which had not been cultivated before planting—Russian thistles, weedy grasses, and sunflowers were most common. Clipping aided materially in reducing competition from weeds. Frequent clippings close to the surface practically eliminated the weeds.

The northern sources began to flower 7 weeks after the planting date. One month later all sources were in bloom.

The southern sources attained a height of about 16 inches, the central sources 14 inches, and the northern sources 8 inches.

In the plots where the weeds were killed before seeding, the southern sources had the highest per cent of ground cover and the northern grasses the least. In the weedy plots where the seed was planted in untilled soil and the

weeds clipped, the northern source increased in per cent of cover more than the above treatment and even exceeded the central and southern sources.

All sources produced very little cover on the unclipped-uncultivated treatment. Competition of grasshoppers, shading by plants, and lack of moisture caused great mortality among seedlings.

This report is not conclusive and due to limited investigation can only show trends.

Apparently better results will be obtained if the weeds are destroyed by cultivation before planting if seeding is to be done late in the spring.

It appears that northern blue grama grass is more resistant to grasshopper damage than that from central and southern sources and establishes itself better under weeds than the other sources if the weeds are mowed occasionally during the first growing season. Where weeds are numerous and are neither destroyed by cultivation before planting nor by clipping or mowing afterward, blue grama seedlings from any source have little chance of establishing themselves.

LITERATURE CITED

1. RIEGEL, D. A. A study of the variations in growth of blue grama grass from seed produced in various sections of the Great Plains Region. Trans. of the Kans. Acad. of Sci. 43:155-171. 1940.
2. HOPKINS, HAROLD. Variations in the growth of side-oats grama grass at Hays, Kansas, from seed produced in various parts of the Great Plains Region. Trans. of the Kans. Acad. of Sci. 44: 86-95. 1941.
3. HASE, CECIL L. The effect of clipping and weed competition upon the spread of pasture grass seedlings. Trans. of the Kans. Acad. of Sci. 44: 104-111. 1941.

14

The Effects of Different Intensities of Grazing Upon Three Varieties of Wheat in Western Kansas

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The purpose of this study was to determine the effect of grazing upon the yield and the development of roots and of other structures of three varieties of hard winter wheat.

The wheat plant has been studied by many investigators. Some have made observations on the plant as a whole while others have specialized on its various parts, but to the author's knowledge, little data have been published on the effects of grazing upon root penetration and yield of the wheat plant.

Hard winter wheat, the type most commonly grown in western Kansas, is a winter annual which is planted in the fall of the year and matures early the following summer. The three varieties of this type of wheat chosen for observation were turkey, a late maturing wheat, tenmarq, which matures a few days earlier than turkey, and early blackhull, which, as its name implies, is one of the first varieties to complete its growth.

Mr. A. F. Swanson of the Fort Hays Experiment Station furnished certified seed and also gave the author many hints and aids in carrying out the experiment.

The plot in which the seed was planted was located near the center of a much larger field and on a north facing slope of not more than 3 per cent with no visible signs of erosion. The field had been summer-fallowed the year prior to the seeding. A modern drill of the semi-deep furrow type was used to seed the wheat. The rows were planted thirty inches apart instead of the standard ten inch spacing used by most farmers (Fig 1). This greater width was used to make it more convenient to remove and study the root developments. The seed was planted at the rate of sixty pounds per acre and at an average depth of 1.5 to 2 inches. The rows were approximately 120 feet long and ran approximately on the contour. The rows were arranged somewhat as follows: On the south the first row was planted to turkey; the second row to tenmarq, and the third to early blackhull. This arrangement was duplicated three times, making a total of nine rows in the plot. Before the wheat was pastured the plot was divided into three equal parts. The middle one-third was fenced to keep out livestock. The west one-third was left open to grazing and the east one third was clipped each week to a height of 1 inch in addition to the grazing as given the west one-third.

EXPERIMENTAL DATA

The seed was planted on summer-fallowed ground, on September 24, 1941. The plants began to emerge on the first day of October, 6 days after planting. No difference in emergence was noted with regard to variety. On October 6 most plants had emerged and a count was taken to determine the number of plants per linear foot in each variety. The number of plants per linear foot were: early blackhull 13.6, tenmarq 15.0, turkey 16.4 Plants from each wheat

variety were removed and studied, and the roots were measured for depth each successive few days until late in December. The development and increase in tillers and adventitious roots were noted and recorded.

On November 4, examination showed the plants of the various varieties had developed 5 to 6 tillers from the crown node and 1 to 2 tillers at the sub-crown node. Due to a blanket of snow some days previous the tillers were assuming a prostrate position.

Both seminal and adventitious roots had penetrated to a depth of about 12 inches. There were many root hairs on the adventitious roots and much branching below 4 inches.

The college dairy cows were turned on the wheat November 4 and were allowed to graze the east and west portions of this project. By the end of November the plants of each variety had produced an average of 8 tillers and an equal number of crown roots on each plant. Some of the crown roots and an occasional seminal root had penetrated well over 3 feet.

A trench was dug across the rows during the last few days of December to

LIST OF FIGURES

Fig.
1. View of the project showing the rows 30 inches apart and the fenced exclosure in the center. The wheat plants are about 2 months old.
2. View taken May 20, 1942, showing the early blackhull headed in the ungrazed area while the turkey and tenmarq (on each side of the author) have scarcely started to head.

permit study of roots. There had been little increase in tillers or roots since November but some of the roots (1 to 4 to a plant) had penetrated to a depth of 61 inches. About 75 per cent of the roots had followed the paths of old roots and earthworm burrows (1). The remainer of the roots were confined to the upper 18 to 24 inches of the soil, with an average lateral spread of 8 to 10 inches.

Observations were discontinued until February, due to snow and freezing weather. No clippings were made during this period and only occasional grazing was done by the cattle.

On February 7 another trench was dug to determine the extent of root growth. The bulk of the roots of the overgrazed plants were in the upper 24 inches. Several had penetrated to 48 inches but only one root had gone to a depth of 70 inches. In the moderately grazed plants the root branchings were more numerous and the bulk of the roots were found in the upper 24 to 32 inches. There were several roots that had gone down to as much as 72 inches and many were down to 48 inches. In most cases the deep roots had followed the line of least resistance by traveling the paths of former roots or earthworm burrows. There was no difference between the depth of root penetration of the moderately grazed and the non-grazed plants. The non-grazed plants, however, had a much greater lateral spread of roots in the top foot of soil and the roots were more branched.

On March 10 a new plan for study of the roots was initiated (2). In order to determine more accurately the actual amount of roots which were in each 6 inches of soil a soil block method was used. Blocks 30 inches long, 20 inches wide and 6 inches thick were removed, taken to a screening table and here the soil was washed free from the roots. These roots from each layer were taken to the laboratory, oven-dried and then weighed. By using this method a close approximation of the actual amount of roots per foot could be measured and a comparison could be made between the overgrazed, the non-grazed and the moderately grazed. The comparative weights of the roots in the top 6 inches of the 3 grazings were as follows: non-grazed, 12.39 grams, moderately grazed, 8.01 grams., overgrazed, 3.4 grams. The weights for the next 6 inches were: non-grazed, 6.26 grams., moderately grazed, 3.4 grams., and the overgrazed, 1.39 grams.

It was the hope of the author to carry out this washing method of study of each layer of soil down to 6 feet, but because of the great amount of work and the lack of time the study was limited to the top 12 inches.

The cattle were removed from the plot on April 12 and clippings were discontinued on all but 3 of the rows. These 3 rows which were one of each of the 3 varieties of wheat being studied were clipped short until April 24. These plants were clipped late to determine if late grazing had any effect upon the yield.

On May 11, the plants were measured to see how the clipped plants compared with the others. At this date the clipped plants were only 12 to 14 inches tall. The non-clipped and non-grazed plants were much taller, some of them as much as twice as tall. They also appeared thicker as the clipping tended to have a thinning effect. There did not seem to be any difference between the non-grazed and the moderately grazed plants which were not clipped after April 12.

The early blackhull plants first began to head about the 19th of May (Fig. 2). From 15 to 35 per cent of the non-grazed plants of this variety were headed on this date. This is marked contrast to the scattered heads of approximately 2 per cent on both of other varieties. Of the moderately grazed plants, 10 to 12 per cent were headed out in the early blackhull, while none of the other two varieties had developed to this extent. None of the overgrazed plants were headed. This would lead one to believe that the grazing of the wheat plant had a tendency to make it head at a later date.

As the season for maturity progressed the early blackhull retained the lead in heading. It not only headed first but it lost its foliage much earlier than the other two varieties and was taller at maturity. The turkey had many more crooked joints and much heavier foliage than either of the other two.

On May 29 and 30 the last root studies were made. At this time the trench was dug to a depth of 80 inches. The roots of both the moderately grazed and overgrazed plants had penetrated to 75 inches. Most of the roots stopped at a depth of 65 inches due to a layer of hard black soil The plants that were clipped as late as April 24 had only a few roots that reached the black layer at 65 inches. There were comparatively few roots of the severely clipped plants that went to a depth of 4 feet, most of the roots being in the upper 18 inches. Several extended to 36 inches. In the moderately grazed and the non-grazed treatments there were numerous roots at 36 inches and on down to nearly 4 feet. Below this depth the roots became very few. In all cases by far the majority of the roots were confined to the top 18 inches of soil. The top 6 inches of soil was very dry at this digging and the roots in this layer of dry soil were fibrous and tough and without root hairs, while those in the moist soil below were finely branched and covered with numerous root hairs.

YIELD DATA

On the evening of June 27 a bolt of lightning set fire to the wheat field in which the project was located and it narrowly escaped destruction. A portion of the south three rows on the east end were burned and the south two rows on the west end had the awns singed from the heads. A downpour of rain accompanied by hail extinguished the fire. The hail and driving rain did some damage to the wheat in the project, breaking over many heads.

Harvesting of the wheat was begun on June 29 All the heads were collected from a section 14 feet in length in the east, the central, and the west

TABLE I. Comparative data on height and number of stalks, number of heads, grasshopper damage, and yield per acre of three varieties of hard winter wheat, turkey, tenmarq, and early blackhull under different intensities of grazing

Variety	Treatment	Height of plants	Stalks per ft. Total	Stalks per ft. Broken	Heads per ft Total	Heads per ft Broken	Hds damaged by grasshoppers per ft	Yield in bu. per acre
	late heavy grazed	30″	101	45	56	18	20	31.5
Turkey	heavy grazed	32″	113	76	58	27	20	31
	mod grazed	33″	109	45	61	19	21	31.2
	ungrazed	40″	132	72	83	35	21	35.5
	late heavy grazed	33″	103	61	66	36	22	36.4
Tenmarq	heavy grazed	34″	93	67	57	36	20	36.8
	mod. grazed	35″	99	55	65	30	21	39.1
	ungrazed	38″	103	69	72	41	18	43 5
	late heavy grazed	33″	89	47	61	23	7	31.1
Early	heavy grazed	35″	97	65	65	39	8	51
Blackhull	mod. grazed	36″	105	60	70	33	8	59.5
	ungrazed	43″	132	70	84	34	7	51 8

third of each row. The harvested heads were then threshed by hand and the yield of each section computed in bushels per acre.

Other data were collected including average height of plants in each treatment, and the average number of stalks and heads per foot. This information is compiled in Table 1.

HEIGHT OF PLANTS:

The ungrazed wheat grew to the greatest average height in each variety while the least growth was noted in the late grazing treatment for each variety. Early blackhull produced the greatest average height of stalks in each treatment followed by tenmarq and turkey in the order mentioned except that turkey was slightly taller than tenmarq in the ungrazed treatment.

NUMBER OF STALKS AND HEADS:

The number of stalks per foot in the row was found on the average to be greatest in the ungrazed and fewest in the late heavy grazed treatments of the three varieties. Early blackhull and turkey each produced 132 stalks per foot in the ungrazed treatment and tenmarq 103, while in the late heavy grazing treatment tenmarq had 103 stalks per foot, turkey 101, and blackhull 89.

In each variety the number of heads per foot was greatest in the ungrazed treatment and with the exception of the tenmarq they were fewest in the late grazed treatment. The early blackhull had 84 heads per foot in the ungrazed plants, while turkey had 83, and tenmarq 72 in the same treatment. Where late heavy grazing was used, tenmarq produced 66 heads per foot, early blackhull 61, and turkey 56.

YIELD PER ACRE:

The yield from the ungrazed treatment exceeded the yields of other treatments with turkey and tenmarq, but was less than the yield under moderate grazing for early blackhull.

In all treatments, except heavy grazing, early blackhull outyielded the other varieties. The ungrazed blackhull yielded 51.8 bushels per acre, while tenmarq yielded 43.5 and turkey 35.5 bushels per acre under the same treatment. Early blackhull where moderately grazed, yielded 59.5 bushels to the acre while moderately grazed tenmarq produced 39.1 bushels and turkey 31.2 bushels per acre.

The yields per acre respectively where heavy grazing was practiced, were early blackhull 51 bushels, tenmarq 36.8 bushels, turkey 31 bushels. Under the treatment of late heavy grazing, early blackhull, turkey and tenmarq yielded 31.1, 31.5, 36.4 bushels per acre respectively.

SUMMARY

Three varieties of hard winter wheat, turkey, tenmarq, and early blackhull were used in the experimental treatments.

During the first four months of growth the plants of each variety produced an average of 8 to 9 tillers and an equal number of crown roots. Some of the crown roots penetrated to a depth of 61 inches. During the cold period from December to February, a few of the roots penetrated to a depth of 72 inches but there was no increase in the number of roots or tillers. On March 10, non-grazed plants had the most roots and overgrazed the fewest by weight in first foot of soil.

Cattle were allowed to graze the wheat from November 4, 1941, to April 12, 1942, a period of 190 days. Clipping was continued on one row of each

variety until April 24, 1942, to determine if late grazing affected yield.

The greatest depth of root penetration was 75 inches. Several roots were found at depths of 3 to 6 feet in non-grazed and moderately grazed and plants with few roots at the same depth were found in overgrazed plants. There was no apparent varietal difference in rate of growth or dept of penetration of roots. Early blackhull, both non-grazed and moderately grazed, began to head May 19, 1942, 258 days after planting. This was a few days ahead of the other varieties. The non-grazed and moderately grazed treatments headed before the late overgrazed treatment in each variety indicating that late grazing retards production of heads.

Early blackhull produced greatest yield per acre in all treatments, except late, heavy overgrazing in which treatment it was exceeded by both the other varieties. Tenmarq and turkey each produced its greatest yield per acre in non-grazed treatment and least in late heavy grazed treatment. Early blackhull produced greatest yield under moderately grazed treatment and least in late heavy grazed treatment.

The relatively high yields per acre which were obtained were influenced possibly by optimum moisture content of the soil, wide spacing of the rows and harvesting and threshing of the heads from small areas by hand.

LITERATURE CITED

1. Weaver, J. E. and Clements, F. E. 1942. *Plant ecology.* McGrew-Hill, New York. Second Edition, p. 302.
2. Pavlychenko, T. K. 1937. The soil-block washing method of quantitative root study. Canadian Jour. of Research, Vol. 15, Sec. C.

The Effect of Season of Growth and Clipping on the Chemical Composition of Blue Grama (Bouteloua Gracilis) at Hays, Kansas

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Blue grama (*Bouteloua gracilis*) is one of the most important forage plants in the Great Plains grazing region. It is found over a much larger area than buffalo grass (*Buchloe dactyloides*) (Shantz, 1923). The proper use of this valuable forage plant can be determined most effectively if something is known concerning its chemical composition in various stages of growth and under various intensities of grazing. The purpose of this research was to determine both the effect of repeated clipping and uninterrupted growth on the chemical composition of blue grama. The constituents sought were moisture, dry matter, ash, calcium, phosphorus, fat, crude protein, crude fiber, and nitrogen-free extract (N-free-extract).

RELATED STUDIES

According to Hopper and Nesbitt (1930) the moisture content of the young, vigorously growing plant is much higher than at any other stage in the development of the plant. This was further substantiated by Lush (1933) who concluded that the moisture content lowered with the advance in the season. There have been some variations in different regions in regard to the ash content during the growing season. Lush in Louisiana and Hopper and Nesbitt in North Dakota found very insignificant ash fluctuations in hay and pasture grasses. Stoddart and Greaves (1942), however, found a tendency for the total ash content to decrease throughout the growing and late summer season in the rather arid regions of Utah. They found that phosphorus decreased quite noticeably while calcium remained practically constant. Morrison (1941) says that forage plants contain much more phosphorus and calcium in their early growth stages than in later stages. Stanley (1938) confirmed the tendency for calcium and phosphorus to decrease in range grass in Arizona through the season. An interesting study by Watkins (1937) reveals a daily need for twenty grams of calcium and ten grams of phosphorus per head in mature cattle in the New Mexico range country. In order that the need be supplied, the calcium should not fall below 0.25 per cent and phosphorus not below 0.12 per cent. Stanley has made the same observations on the grassland ranges in Arizona.

Nearly all have observed a decrease in the percentage of total protein through the season in the common pasture grasses. These include Stoddart and Greaves from Utah, Lush from Louisiana, Hopper and Nesbitt from North Dakota, Shutt (1929) from Canada, Stanley from Arizona, and Dustman and Van Landingham (1930). Brown (1939) of Missouri found a correlation between temperature and the percentage of protein. The protein decreased slightly when the temperature was between 40° and 60° F. and increased when the temperature reached 70° to 100° F.

These men just previously mentioned were fairly well agreed that the crude

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fiber and the nitrogen-free-extract increased with the advance in the season. Fraps and Fudge (1940) also found a general increase in crude fiber and N-free-extract in the forage grasses of the East Texas timber country. Dustman and Van Landingham found a marked increase in the fiber content in *Andropogon virginicus* and *Danthonia spicata* about the first week in July. They also found that it took about three weeks after an area had been clipped before the grasses began to show much increase in the percentage of crude fiber. Brown has also found a decline in the percentage of N-free-extract when the temperature began to rise.

There is some difference in the findings of various individuals in the trend of fat percentages in different localities. Hopper and Nesbitt and Lush found very little change in the percentage of fat found in pasture grasses in two widely different localities. According to Stoddart and Greaves the percentage of fat increased in the Utah grasses Jones and Huston (1914) found an increase in fat through the season in the corn plant, but it was concentrated in the ear as it neared maturity. A very interesting statement from the Rocky Mountain Forest and Range Experiment Station report (1942) intimated that cattle cease to gain rapidly in the late summer because of a lack of protein in the forage and possibly a lack of calcium and phosphorus.

ENVIRONMENTAL CONDITIONS

The samples of blue grama that were analyzed in this study were taken from the open pastures near Hays, Kansas. The top soil is rich and rather dark in color. The carbonate layer is found between 18 inches and 32 inches inclusive, below the surface. (Albertson, 1937). The rainfall through the season of collecting was somewhat above the normal for that season of the year. The total rainfall by months (Flora, 1941) and the per cent available soil moistures (Albertson and Weaver, 1943) during the collecting period are given in Table I. No chemical analysis has been made of the soils from which those samples were taken.

TIME AND METHOD OF SAMPLING

The samples for this study were collected during the summer, fall, and winter of 1941. The first clipping was made May 17, and new clippings of the same areas were made at approximately two-week intervals until the end of the growing season. The last clipping was made on January 31, 1942, to show the effects of weathering on the mature grass. Reclippings were made on the original plots whenever there was sufficient forage for a satisfactory clipping.

TABLE I Inches of rainfall by months and the percentage of available soil moisture through the season of 1941.

Date	Rainfall, inches	Date	Per cent available soil moisture
May	2 86	May 5	18 8
June	6.40	June 9	27.0
		June 23	13.4
July	0 63	July 7	13.0
		July 21	0.5
August	4.14	August 4	–1.0
		August 19	10.0
September	3.02	September 1	10.5

The plots were clipped with a pair of hand clippers. The grass sample was weighed in the field to obtain the fresh or field weight and brough to the laboratory for killing. The samples were killed by raising their temperatures to

about 110° C. for an hour after which they were allowed to dry in the air. The air dry weight was also taken.

METHODS OF ANALYSIS

The procedures of analysis were taken from the Association of Official Agricultural Chemists (1940) with the exception of the phosphorus procedure which was taken from Talbot's Quantitative Chemical Analysis (Hamilton and Simpson, 1937). Nitrogen-free-extract (N-free-extract) was determined by subtracting the percentages of water, ash, protein, fiber, and fat from 100 per cent

RESULTS

The moisture content of the different samples of blue grama had a marked tendency to decrease through the season. The samples of reclipped forage showed a consistently high moisture content throughout the clippings. The dry matter was the exact opposite of the moisture. It increased through the season and was comparatively low in the new growths (Fig. 1).

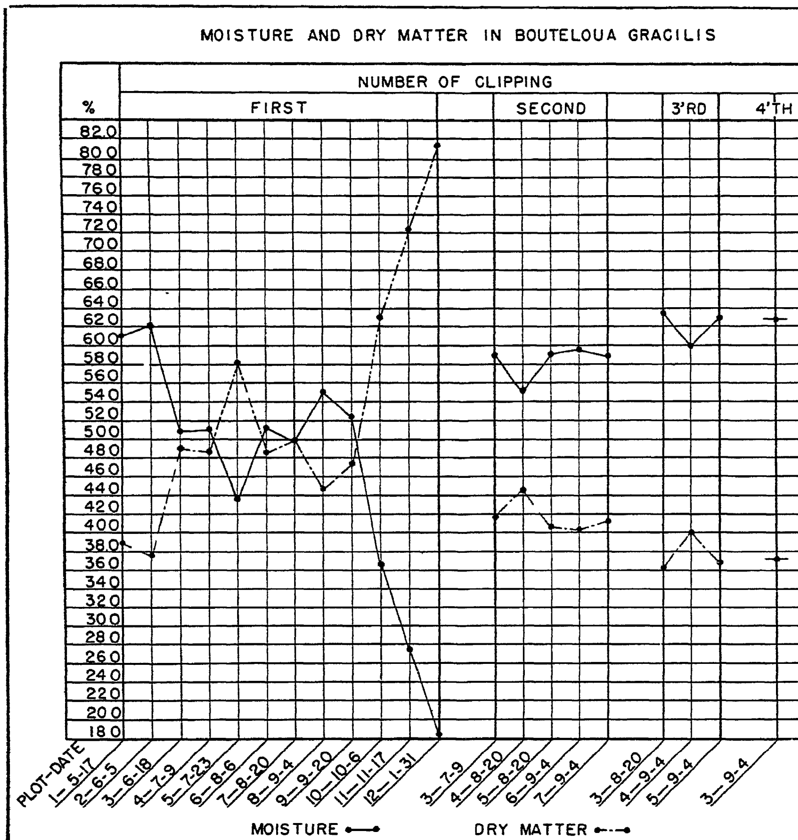

FIGURE 1. Variation in percentage of moisture and dry matter of *Bouteloua gracilis* as affected by length of growing period and season of growth.

The percentage of ash increased in the first clippings until the end of the growing season. After the growing season, the ash content decreased quite rapidly. The ash content of the reclippings averaged about the same as the first clippings, but there was a wide variation in the reclipped ash percentages. The calcium and phosphorus content of the ash seemed to remain relatively steady until the middle of the summer or near the end of the growing season. The second, third, and fourth clippings showed no average increase or decrease in the percentage of calcium or phosphorus; however, both increased somewhat from the first to the last of the reclippings.

The percentage of fat in the first clippings increased, after a drop for nearly one month, until it reached a peak in mid-summer. The fat percentage increased in the second clipping but decreased in the third clipping.

The percentage of crude protein showed the greatest variation of any constituent in the grass samples. The first clippings showed an almost continuous downward trend from the first to the last. The protein content of the second,

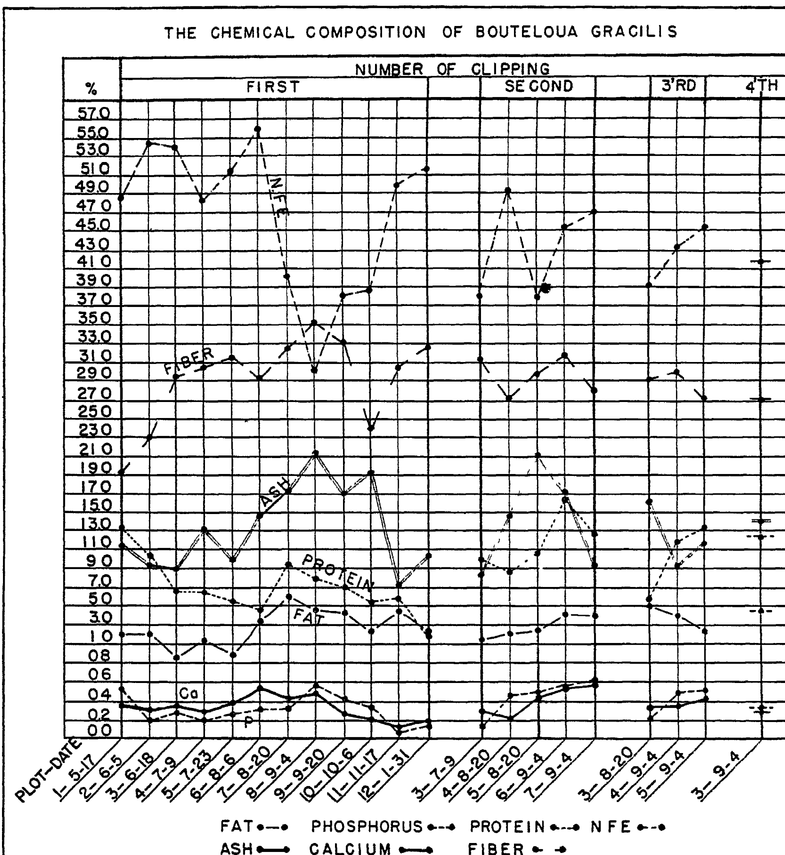

FIGURE 2. Variation in percentage chemical composition of *Bouteloua gracilis* as affected by length of growing period and season of growth.

third, and fourth clippings was noticeably above the average of the first clippings.

The fiber content showed a definite upward trend through the first clippings but did not show any definite trends in the second and third clippings.

The percentage of N-free-extract showed a very definite trend downward in the first clippings until the first of September when it again increased until the end of the season The N-free-extract in the second, third, and fourth clippings showed some variations, but the general trend was toward an increase. Graphs of chemical composition are shown in figures 1 and 2.

DISCUSSION OF RESULTS

The fluctuation in the percentage of moisture and dry matter seemed to be influenced by the quantity and frequency of the summer rains. The increase in the ash percentage shows a contrast to the findings of Stoddart and Greaves in that they found ash content decreased in the arid regions of Utah. The sharp rise in percentage of protein in the first clipping made August 20, followed a time of soil moisture after a very dry sell. The variations in the per cent chemical composition is shown in Table 2.

TABLE II Per cent chemical composition of *Boutcloua gracilis*, Hays, Kansas.

Plot and Date	Moisture	Dry Matter	Ash	Calcium	Phosphorus	Fat	Protein	Fiber	N F.E
1 — 5-17	61 0	39 0	11.3	0.38	0 56	2 10	13.3	19 2	48.8
2 — 6-5	62.1	37.9	9.5	0.34	0.21	2 20	10.5	23.0	54.7
3 — 6-18	50 9	49 1	9.0	0 37	0.33	0.84	6.7	29.4	54 1
4 — 7-9	51.3	48.7	13.1	0 33	0 21	1.19	6.6	30.6	48.4
5 — 7-23	41.8	58.2	10.1	0.40	0 28	0.88	5.7	31 6	51.6
6 — 8-6	51.4	48 6	14.8	0.56	0 35	3 30	4.5	29.6	56.0
7 — 8-20	50.0	50.0	17.5	0.44	0.36	6.00	9.5	32.6	40.2
8 — 9-4	55 2	44.8	21.7	0.49	0.57	4.80	8.1	35 1	30.4
9 — 9-20	52.5	47.5	17.1	0.29	0.46	4.40	7.1	33.1	38.2
10 — 10-6	36 8	63.2	19.5	0.21	0.35	2 50	5.2	24 0	38.9
11 — 11-17	27.5	72.5	7.3	0.14	0.11	4.50	6.0	30 6	49.9
12 — 1-31	18.4	81 6	10.6	0 20	0 18	2.60	2 4	32.8	51.6
				Second Clipping					
3 — 7-9	59.1	41.9	8 6	0.31	0.17	1.53	10.2	31 6	38.0
4 — 8-20	55.3	44.7	14.5	0 22	0.47	2 20	5.4	27.3	49 2
5 — 8-20	59.3	40.7	21 2	0 44	0 44	2.50	8 8	29.8	37.9
6 — 9-4	59.8	40.2	17 2	0 55	0 57	4 20	16.4	31 9	45.4
7 — 9-4	58.9	41.1	9.2	0.59	0 62	3 90	12.8	28.2	47.0
				Third Clipping					
3 — 8-20	63 8	36.2	16.3	0 36	0.25	5.00	5.4	29.1	39.0
4 — 9-4	60 0	40.0	9.3	0 37	0.50	4.10	12.1	30 2	43.2
5 — 9-4	63.2	36.8	11 7	0.44	0.52	2 40	13 5	27.2	45.2
				Fourth Clipping					
3 — 9-4	62.7	37.3	13 9	0 29	0 32	4 50	12 4	27 1	41 8
Season Average	52 3	47.6	13.2	0 37	0 37	3 29	8 75	29 0	45.0

CONCLUSIONS

The tendency for blue grama to become unpalatable to livestock is indicated in these analyses by the decrease in moisture, the decrease in protein and N-free-extract, and the increase in fibrous material in the first clippings. The second clipping and recurrent clippings have been a deciding factor in retaining a higher percentage of both water and protein. This may be an answer to the question, "Why do cattle graze some areas off short while other areas are untouched?" It certainly has a direct relation to the frequency of loss in weight of cattle in late summer as mentioned in the report of the Rocky Mountain Forest and Range Experiment Station.

According to Watkins for best results with cattle, their forage should contain about 0.25 per cent calcium and 0.12 per cent phosphorus. On that basis,

cattle wintered on blue grama should be supplied with a supplement rich in protein, calcium, and phosphorus.

The Agricultural Conservation Program has given conservation credit to the ranchman who would defer his pasture until August 1, or withhold the stock from the range until that time. This practice is hardly justifiable except where revegetation has become necessary because much of the value of the forage is wasted under such a practice.

ACKNOWLEDGMENTS

The work of collecting these samples for analysis was done by Carrol Deyoe.

LITERATURE CITED

ALBERTSON, F. W. 1937. Ecology of the mixed prairie in West Central Kansas. Ecological Monog. 7: 491-2.

ALBERTSON, F W., and WEAVER, J. E. 1943. Effects of drought, dust, and intensities of grazing on cover and yield of short grass pastures of West Central Kansas. In press.

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS, FIFTH EDITION. 1940. Association of Official Agricultural Chemists. Washington, D. C.

BROWN, E. MARION. 1939. Some effects of temperature on the growth and chemical composition of certain pasture grasses. University of Missouri Bulletin 299. 76 pp.

DUSTMAN, R. B., and VAN LANDINGHAM, A. H. 1930. The chemical composition of consecutive cuttings of *Andropogon virginicus* and *Danthonia spocata*. Journal of the American Society of Agronomy 22: 719-24.

FLORA, S. D. 1941. Climatological data. U. S. Department Comm Weather Bureau, Topeka, Kansas.

FRAPS, G. S., and FUDGE, J. F. 1940. The chemical composition of forage grasses of the East Texas Timber Country. Texas Agricultural Experiment Station Bull. No. 582. 35 pp.

HOPPER, T H. and NESBITT, L. L. 1930. The chemical composition of some North Dakota pasture and hay grasses. North Dakota Agricultural College Bull. 236. 38 pp.

JONES, W. J., and HUSTON, H. A. 1914. Composition of maize at various stages of its growth. Purdue University Agricultural Experiment Station Bull. No. 175, Vol. XVII: 599-630.

LUSH, R. H. 1933. Seasonal composition of pasture grasses. Journal of Dairy Science, 16 (No. 2) : 149-52.

MORRISON, F. B. 1941. *Feeds and Feeding,* 20th Edition. Morrison Publishing Company. pp. 106.

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION REPORT. 1942. Range Management Section.

SHANTZ, H. L. 1923. The natural vegetation of the Great Plains Region. Annals of the Association of American Geographers, 13: 89.

SHUTT, FRANK T. 1929. The protein content of grass as related to stage of growth Transactions of the Royal Society of Canada, Third Series, 23: 133-40, Sec. III.

STANLEY, E B. 1938. Nutritional studies with cattle on a grassland-type range in Arizona. Arizona Agricultural Experiment Station Tech. Bull. No. 79.

STODDART, L. A., and GREAVES, J. E. 1942. The composition of summer range plants in Utah. Utah Agricultural Experiment Station, Bull. 305. 22 pp.

HAMILTON, L. F., and SIMPSON, S. G. 1937 *Talbot's Quantitative Chemical Analysis*, Eighth Edition. Macmillian Company. pp. 223-30.

WATKINS, W. E. 1937. The calcium and phosphorus contents of important New Mexico range forages. New Mexico Agricultural Experiment Station Bull. 246 (Tech.). 75 pp.

16

The Elasticity, Breaking Stress, and Breaking Strain of the Horizontal Rhizomes of Species of Equisetum

INTRODUCTION

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Gates first observed that horizontal rhizomes of *Equisetum fluviatile* are quite elastic and defy breaking by manual stretching. There is not much known about stress-strain relations of plants. The following experiments were therefore undertaken to determine such relations for horizontal rhizomes of species of Equisetum in the vicinity of the Biological Station of the University of Michigan during July and August, 1942.

I wish to express my appreciation to Dr. F. C. Gates for the general problem which he suggested and to Dr. A. H. Stockard, Director of the Station, for the use of laboratory facilities.

METHOD

The rhizome is held horizontally between two clamps (Fig. 1), of which one is fixed. The movable clamp and a pan with weights are connected by a piano wire.

We get the stress-strain curve of a rhizome of Equisetum by measuring stress and corresponding strain. The weight of F grams or F·980 dynes acts as tension; then stress $f = \frac{F \cdot 980}{A'} \frac{\text{dynes}}{\text{cm}^2}$ where A′ cm^2 is the area of the cross-section of the rhizome. The corresponding strain of the rhizome is $E = \frac{e}{l}$ where e cms. is the elongation produced by weight F grams. If we plot a curve with E as abscissa and f as corresponding ordinate we get the stress-strain curve. This curve of *Equisetum fluviatile* generally is twice bent or S-shaped (Fig. 6).

EXPLANATION OF FIGURES

PLATE I

FIG. 1. The experimental apparatus: two clamps (the left fixed) hold the piece of rhizome in split rubber stoppers, a pan for weights is attached to the movable clamp thru a pulley by piano wire. A rubber mat on the floor takes the shock of falling.

FIG. 2. A modification of the apparatus for the most delicate rhizomes: the rhizome is held above in a split rubber stopper in the fixed clamp, a thread tied to the lower end of the rhizome suspends the weights.

FIG. 3. Cross section of a rhizome of *Equisetum fluviatile*, showing air chambers and an enlarged portion, showing the cells with thick walls, the walls containing suberin.

FIG. 4. Cross section of a rhizome of *Equisetum sylvaticum*, showing the location of an outer ring of thick-walled black cells and two inner cylinders of thick-walled redbrown cells: enlargements show details—black cells (above) and redbrown cells (below).

FIG. 5. Cross section of a rhizome of *Equisetum arvense* showing air chambers; and an enlargement showing, from outside in, redbrown cells, yellow-brown cells and collenchyma.

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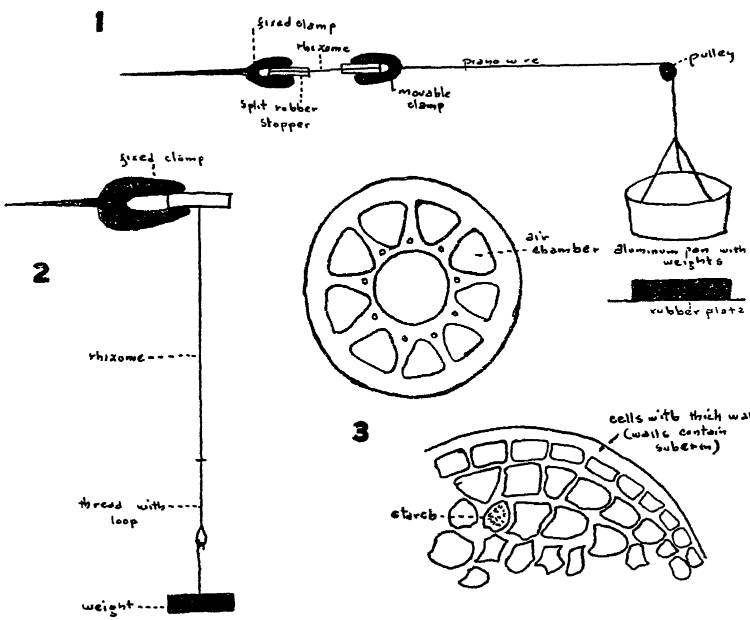
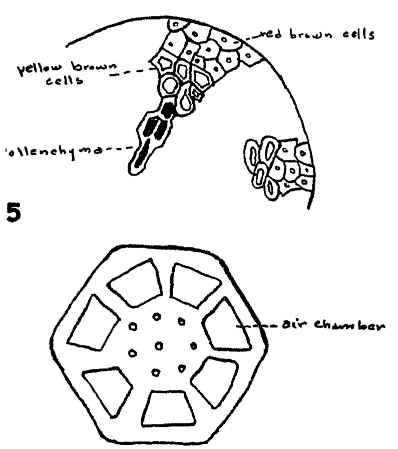
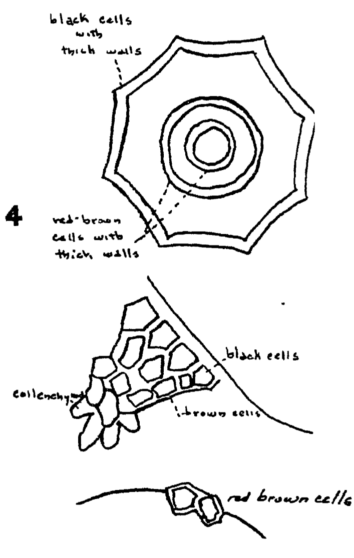


Equisetum fluviatile





Equisetum arvense **Equisetum sylvaticum**

PLATE I

Figure 7 gives the stress-strain curve for steel. The strain of steel remains microscopically small for large stresses until the elastic limit is reached. Until this limit is attained f is proportional to E (Hooke's Law). After this limit is reached the strain increases more rapidly than the stress. *Equisetum fluviatile* rhizomes with S-shaped stress-strain curves behave in a quite different manner than steel. In the region of low tension a large strain increment corresponds to a given small stress increment. When high tensions are reached a small strain increment corresponds to the same given stress increment. The first part of the S curve of *Equisetum fluviatile* corresponds to the elastic condition. The rhizome is elastic if after stretching and releasing it returns to the original state. According to the usage of language, elastic things, like rhizomes of *Equisetum fluviatile* or rubber, allow large deformations before surpassing the limit of elasticity. In physics we say steel is more elastic than rubber because the modulus of elasticity for steel is larger than the modulus for rubber. It is wiser not to use the physical definition of strength of elasticity for rhizomes. *Equisetum fluviatile* rhizomes are very elastic because a small stress produces a great strain if we are on the elastic part of the curve. If we have two different stress-strain curves of two rhizomes befor the limit of elasticity is reached then a certain strain is produced by two different stresses. Now the rhizome under smaller stress is more elastic.

Equisetum Fluviatile

I. Stress-strain Curves

The rhizomes of *Equisetum fluviatile* were collected from the shore of Marl Bay on Douglas Lake. They were under two to three feet of water. The curves of Fig. 6 generally are S shaped. Curve IV (based on average values) may be considered as the first part of an S-shaped curve. The first part of this curve gives stress-strain relations in the elastic range. The second, and larger, part of the curve gives stress-strain relations in the range where the rhizome is no longer elastic. The end of the curve is the breaking point for the rhizome. We read here from the curve that breaking stress for *Equisetum fluviatile* rhizomes is $124.5\frac{kg}{cm^2}$, breaking strain 0.472. That means that a rhizome of 10 cms. length breaks if its elongation is 4.72 cms. The breaking stress $124.5\frac{kg}{cm^2}$ is computed from the average of all the measured breaking stresses. These measured breaking stresses are maximal values. For instance, curve III shows that breaking stress $\leq 18.4 \times 10^7 \frac{dyne}{cm^2}$, breaking **strain $\leq$ 0.472.**

It may be asked why curve IV consists only of the first part of the S-curve. The simplest assumption may be that the rhizome had a notch where it was broken easily by a small stress. But it is also possible that *Equisetum fluviatile* rhizome IV had other elastic properties than rhizomes with S-shaped curves. Now there is the interesting fact that vulcanized rubber has S-shaped stress-strain curves like those of the rhizomes of *Equisetum fluviatile* (1).

It is important to know that the amount of deformation exhibited by a rhizome of *Equisetum* under a certain stress (especially under a large stress) varies with the time that the stress is allowed to act. A certain stress changes the elongation during some minutes. The greatest elongation was always measured and it was assumed that then we got the strain belonging to the

stress used. The length of time is also important for getting the stress-strain curves of rubber (2). With *Equisetum fluviatile* we tried to construct an average curve for our results But we may expect that other experiments will give other S-shaped average curves. Elasticity of substances like steel or copper are easily standardized. As it is not possible to define the properties of a rhizome as it is of a metal, in working with rhizomes we must be satisfied with more general results. The same difficulties are experienced in investigating rubber (3)

II. Cross-section of Rhizome of *Equisetum fluviatile*

It is desirable to find out how the elasticity of the rhizome is related to the structure of the rhizome. (Fig. 3). The cross-section shows many air chambers or lacunae. The epidermis consists of cells with thick walls of brown color. These walls probably contain suberin which makes the epidermis impervious to the passage of water. Below the epidermis are cells with thin walls. Hydrophytes generally have roots whose epidermis cells have thick walls which show the reaction of suberin. These roots contain many air chambers (4). The cortex consists of cells with thin walls. That means the roots of hydrophytes are built up like rhizomes of *Equisetum fluviatile*. It is easily understood that the rhizomes of *Equisetum fluviatile,* which are so lightly built up, are very elastic.

EQUISETUM SCIRPOIDES

Equisetum scirpoides rhizomes were collected in Reese's Bog. The rhizomes of *Equisetum scirpoides* are so tender that they were suspended as shown in Figure 2. In this manner we got the stress-strain curve (Fig. 8) which is an average curve of the material investigated. The breaking stress is 124.5 $\frac{\text{kg}}{\text{cm}^2}$ (by chance it equals the value which we found for *Equisetum fluviatile*). The breaking stress for copper wire is about 6000 $\frac{\text{kg}}{\text{cm}^2}$ (5). The elastic part of the curve of *Equisetum scirpoides* is a straight line, therefore we may compute the modulus of elasticity for our rhizomes of *Equisetum scirpoides.*

$$E = \frac{7 \cdot 10^7}{0.049}\ \frac{\text{dynes}}{\text{cm}^2},\ E = 0.143 \times 10^{10} \frac{\text{dynes}}{\text{cm}^2}$$

For vulcanized rubber we find:

$$E \text{ is about } 0.078 \times 10^8 \frac{\text{dynes}}{\text{cm}^2}$$

These results mean vulcanized rubber is more elastic than rhizomes of *Equisetum scirpoides* if we use the biological definition of elasticity and not that of physics. By manual stretching we may easily check this fact. The modulus of elasticity for the rhizomes of *Equisetum fluviatile* investigated is about $\frac{3.7 \times 10^7}{0.09}\ \frac{\text{dynes}}{\text{cm}^2} = 0.41 \times 10^9 \frac{\text{dynes.}}{\text{cm}^2}$

Rhizomes of *Equisetum fluviatile* are less elastic than vulcanized rubber, but more elastic than rhizomes of *Equisetum scirpoides.*

EQUISETUM ARVENSE

Equisetum arvense rhizomes are to be found in both dry and wet habitats. Hence they afford an opportunity for examining the influence of water. *Equisetum arvense* rhizomes of dry habitat were collected in Reese's Bog near roadside; *Equisetum arvense* rhizomes of wet habitat were collected in a small creek of Reese's Bog.

EXPLANATION OF FIGURES

PLATE II

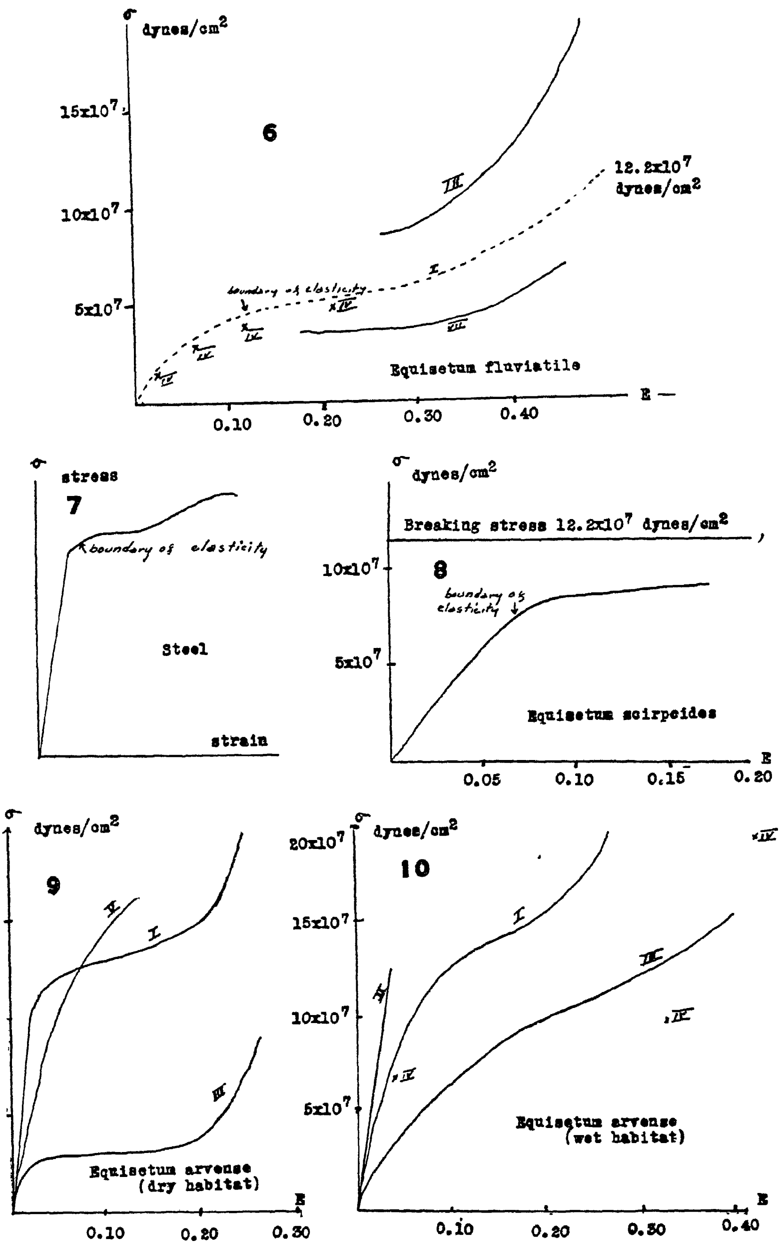
FIG. 6. Stress-strain curves for *Equisetum fluviatile* (wet habitat). The arrow indicates the boundry of elasticity.

FIG. 7. Stress-strain curve of steel, the boundary of elasticity indicated by an arrow.

FIG. 8. Stress-strain curve of *Equisetum scirpoides.*

FIG. 9. Stress-strain curves of *Equisetum arvense* from a dry habitat.

FIG. 10. Stress-strain curves of *Equisetum arvense* from a wet habitat.



6
σ dynes/cm²
15x10⁷
10x10⁷
5x10⁷
12.2x10⁷ dynes/cm²
boundary of elasticity
Equisetum fluviatile
0.10
0.20
0.30
0.40
E
7
σ stress
boundary of elasticity
Steel
strain
8
σ dynes/cm²
Breaking stress 12.2x10⁷ dynes/cm²
10x10⁷
5x10⁷
boundary of elasticity
Equisetum scirpoides
0.05
0.10
0.15
0.20
E
9
σ dynes/cm²
Equisetum arvense (dry habitat)
0.10
0.20
0.30
E
10
σ dynes/cm²
20x10⁷
15x10⁷
10x10⁷
5x10⁷
Equisetum arvense (wet habitat)
0.10
0.20
0.30
0.40
E

PLATE II

In this and the following cases the experimental arrangement shown in Fig. 1 is used to obtain the stress-strain curves. The individual curves are so different that it is impossible to draw an average curve.

The stress-strain curves of rhizomes of *Equisetum arvense,* from the dry habitat, are very steep (Fig. 9). But among the stress-strain curves of rhizomes of *Equisetum arvense* from the wet habitat we find some flat ones (Fig. 10, curves IV, III).

In W Pfeffer (7) we find the statement: "The tensile strength (breaking stress) increases considerably as the imbibed water evaporates from swollen walls." Hence we might assume that rhizomes of *Equisetum arvense* from wet habitats which have imbibed much water, have more flat stress-strain curves than *Equisetum arvense* rhizomes from dry habitats. Later on we will find that Pfeffer's statement is not true for rhizomes and we therefore will have to find another explanation. According to T. Freidenfelt (8) the cortex of roots has more mechanical elements in xerophytes than in hydrophytes. In addition, with increasing hydrophily the central mechanical system of roots becomes weaker; with increasing xerophily, the central-mechanical system becomes stronger. The cross-sections of rhizomes of *Equisetum arvense* from dry habitats (Fig. 5) and *Equisetum fluviatile* from wet habitats (Fig. 3) show that we have the same differences as in roots. In the cortex of rhizomes of *Equisetum fluviatile* (wet habitat) we do not find any mechanical elements. But the cortex of rhizomes of *Equisetum arvense* (dry habitat) has many mechanical elements. The central part of *Equisetum fluviatile* has more lacunae than the central part of *Equisetum arvense.* Hence we find that rhizomes of *Equisetum fluviatile* from wet habitats have flat stress-strain curves because they are lightly built up. Rhizomes of *Equisetum arvense* from dry habitats have steep stress-strain curves because they are heavily built up. It is probable that *Equisetum arvense* rhizomes from wet habitats sometimes have fewer mechanical elements than *Equisetum arvense* rhizomes from dry habitats. This may explain some of the flat curves in Fig. 10. But it is also possible that these flat curves belong to young parts of the rhizome (see later).

EQUISETUM VARIEGATUM NELSONI

The rhizomes of *Equisetum variegatum nelsoni* were collected at Pine Point of Douglas Lake. The stress-strain curves of *Equisetum variegatum nelsoni* are the steepest ones which we investigated. If W. Pfeffer's law is right that the breaking stress increases considerably as the imbibed water evaporates we have to expect very flat curves for turgid rhizomes. Therefore we laid old rhizomes of *Equisetum variegatum nelsoni* in water during 12 hours. After this time we determined the stress-strain curves. We found that curves I and IV of Fig 11 are the steepest ones of all *Equisetum rhizomes* which we investigated. That mean's Pfeffer's law is not true for rhizomes. Curve VIII of Fig. 11 belongs to a dry old rhizome. We should expect a steeper curve than I and IV according to Pfeffer's law but we find a flatter curve. Again we see the law is wrong. The curves V and VII of Fig. 11 belong to young rhizomes. They are very flat. The cross-section of rhizomes V and VII are similar to the cross-sections of *Equisetum fluviatile* rhizomes from wet places. Flat stress-strain curves are found in both cases. This is easily understood because aquatic plants often have juvenile structure.

It is interesting that in *Equisetum variegatum nelsoni* old rhizomes are heavily built up and have steep stress-strain curves, while young rhizomes are lightly built up and have flat stress-strain curves.

Young rhizomes of *Equisetum variegatum nelsoni* have the same flat stress-strain curves and but little mechanical structure similar to old rhizomes of *Equisetum fluviatile* in wet places. Thus the rhizomes of *Equisetum* demonstrate that aquatic plants may have juvenile structure.

A parallel situation is found in rubber (9). The influence of degree of vulcanization (amount of sulfur) brings about differences in the stress-strain curves for vulcanized rubber. (Fig. 12). Curves a and b of Fig. 12 belong to undervulcanized rubber (low breaking stress), c is correctly vulcanized, d is over-vulcanized. As an increase in the amount of sulfur makes the stress-strain curves of vulcanized rubber steeper, the increasing mechanical firmness in rhizomes of *Equisetum* makes stress-strain curves of such rhizomes steeper. Over-vulcanized rubber shows quick appearance of old age (10). The parallel fact is that old rhizomes of Equisetum show strong mechanical structure. Thus by investigation of rhizomes of *Equisetum variegatum nelsoni* we found four new facts for rhizomes.

Equisetum Sylvatum

Equisetum sylvaticum rhizomes were collected in Reese's Bog near the former hermitage. The stress-strain curves of *Equisetum sylvaticum* (Fig. 13) show the lowest breaking stresses on the average. These rhizomes are very heavily built up. (Fig 4.) The epidermis has cells with thick walls and in the interior part we find two cylinders of cells with thick walls. The rhizome is very brittle. So it is reasonable to assume that *Equisetum sylvaticum* is highly specialized *Equisetum arvense* is also highly specialized (11). The rhizome is heavily built up, but less heavily than the rhizome of *Equisetum sylvaticum.* (Fig 5) *Equisetum arvense* rhizomes have small breaking strains (Fig. 9). Hence we may say that *Equiseta* which are highly specialized have rhizomes heavily built up, and either low breaking stresses or low breaking strains.

Equisetum Praealtum

Equisetum praealtum rhizomes were collected in the "Gorge." We can now speak of the possibility of using stress-strain curves in taxonomy. The consideration of stress-strain curves of *Equisetum praealtum* shows (Fig. 14) that the product of breaking stress and breaking strain generally is a constant, i.e. the breaking points of the stress-strain curves of *Equisetum praealtum* generally are on a hyperbola For taxonomy we might mention:

a. *Equisetum praealtum* has a stress-strain curve for rhizomes in which the endpoints are on a hyperbola.
b. *Equisetum fluviatile* has flat S-shaped stress-strain curves for rhizomes (Fig 6).
c. *Equisetum arvense* has steep S-shaped stress-strain curves for rhizomes. (Fig. 9.)

Elasticity of Muscles

There are corresponding stress-strain curves for muscles of animals. For the muscle of a frog we find Fig. 15 (12). In this figure strain is expressed by extension and stress by load. We see that there is similarity between

EXPLANATION OF FIGURES

PLATE III

FIG. 11. Stress-strain curves of *Equisetum variegatum nelsoni*

FIG. 12. Stress-strain curves of vulcanized rubber: a) and b), under-vulcanized (low breaking stress) : c), correctly vulcanized · and d), over-vulcanized.

FIG 13. Stress-strain curves of *Equisetum sylvaticum*

FIG. 14. Stress-strain curves of *Equisetum praealtum*, together with products of certain breaking stresses and strain

FIG. 15. Stress-strain curve of the muscle of a frog.

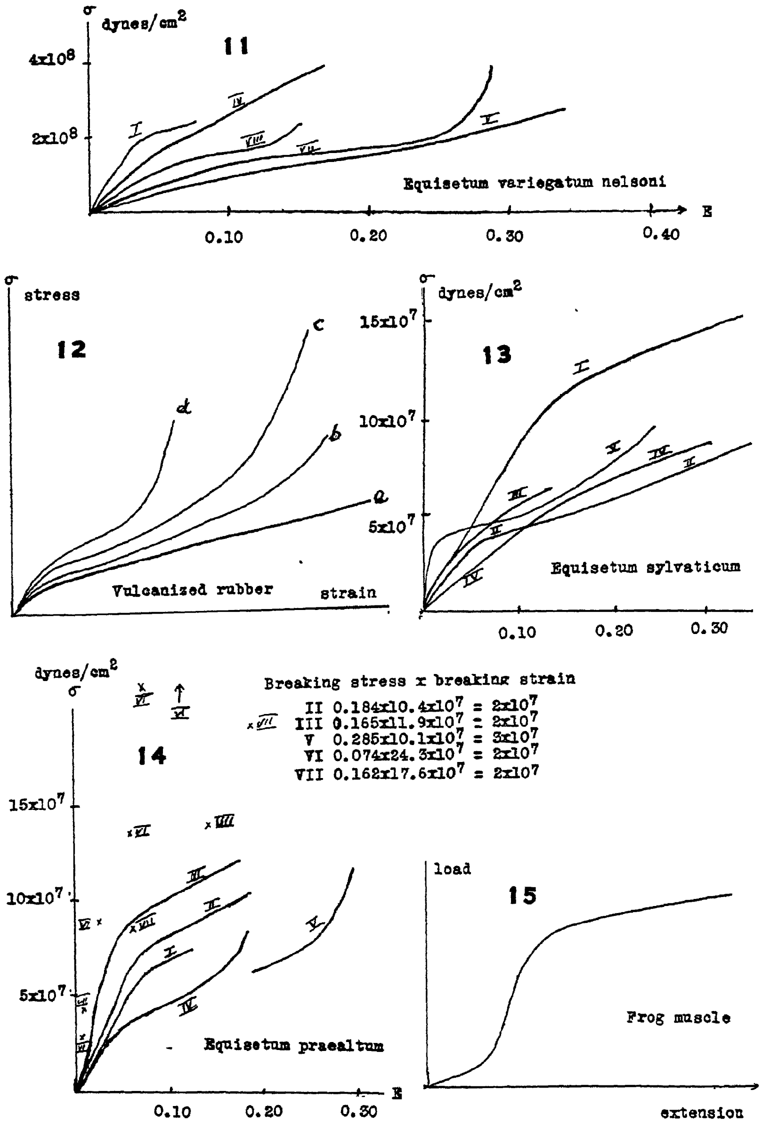

σ dynes/cm²
11
4x10⁸
2x10⁸
I
IV
VIII
VII
V
Equisetum variegatum nelsoni
E
0.10
0.20
0.30
0.40
σ stress
12
d
c
b
a
Vulcanized rubber
strain
σ dynes/cm²
15x10⁷
10x10⁷
5x10⁷
13
I
V
IV
II
III
Equisetum sylvaticum
0.10
0.20
0.30
dynes/cm² σ
14
Breaking stress x breaking strain
II 0.184x10.4x10⁷ = 2x10⁷
III 0.165x11.9x10⁷ = 2x10⁷
V 0.285x10.1x10⁷ = 3x10⁷
VI 0.074x24.3x10⁷ = 2x10⁷
VII 0.162x17.6x10⁷ = 2x10⁷
15x10⁷
10x10⁷
5x10⁷
Equisetum praealtum
E
0.10
0.20
0.30
load
15
Frog muscle
extension

PLATE III

stress-strain curves of rubber, of rhizomes of *Equisetum* and of muscular tissue. Muscles according to Fig. 15 are elastic like rubber bands.

We understand that a muscle in a state of elastic tension contracts more effectively for a given stimulus than one which is entirely relaxed. It is possible that there are also similar stress-strain curves for bones as for rubber. It would necessitate another investigation to find the stress-strain curves of the different living tissues.

SUMMARY

1. Because there was not much known about elasticity of plants, experiments about elasticity of horizontal rhizomes of *Equisetum* were conducted. The experimental device is similar to the device for examining the elasticity of metal wires.

2. The modulus of elasticity is:
   for vulcanized rubber about 0.078×10^8 dynes/cm^2
   for rhizomes of *Equisetum fluviatile* about 4.1×10^8 dynes/cm^2
   for rhizomes of *Equisetum scirpoides* 14.3×10^8 dynes/cm^2
   for copper about 12000×10^8 dynes/cm^2
   for steel 20000×10^8 dynes/cm^2

The elasticity of rubber or living tissue is greater the smaller is the modulus of elasticity.

3. Rhizomes of *Equisetum fluviatile* are lightly built up, very elastic, with stress-strain curves like those of vulcanized rubber. The breaking stress is 124.5 kg/cm^2, the breaking strain 0.472.

4. The lighter built-up rhizomes of wetter habitats are more elastic.

5. The heavier the rhizome is built up the steeper is the stress-strain curve. A parallel fact for rubber is: The greater the amount of sulfur, the steeper are the stress-strain curves of vulcanized rubber.

6. *Equisetum* agrees with other aquatic plants in the frequency of juvenile structure. The more highly specialized have heavily built-up rhizomes, are brittle and have a low breaking stress or breaking strain.

7. Muscles of animals have the same elastic properties as rubber and rhizomes of *Equisetum*. There is a similarity of the structure of muscles and the structure of rubber (13). Hence we may expect to find the same similarity for the structure of rhizomes of *Equisetum*.

LITERATURE CITED

1. K. MEMMLER. Handbuch der Kautschuckwissenshaft (Science of Rubber) p. 577-578. 1930.
2. K. MEMMLER. Ibid.
3. K. MEMMLER. Ibid., p. 436, 437.
4. BIBLIOTECA BOTANICA 61. 1904. Freidenfelt T. Der anatomische Bau der Wurzel in seinem Zusammenhang mit dem Wassergehalt des Bodens. p. 76. p. 83.
5. W. PFEFFER. Physiology of Plants, vol. 2, chapter 4. 1906.
6 K. MEMMLER. Handbuch der Kautschukwissenschaft, p 438.
7. W. PFEFFER. Physiology of Plants, vol. 2, chap. 4.
8. T.FREIDENFELT. "Der anatomische Bau der Wurzel in seinem Zusammenhang mit dem Wassergehalt des Bodens", p 96, p. 106. 1904
9. K. MEMMLER. The Science of Rubber, p. 518.
10. K. MEMMLER. Handbuch der Kautschukwissenschaft, p. 579.
11. EDWARD CHARLES JEFFRY. The Anatomy of Woody Plants, p. 271. 1917.
12. W. HOWELL. Textbook of Physiology, 12th edition, p 22. 1931.
13 D. BURNS. An Introduction to Biophysics p. 176, 177 (Liquid Crystal Theory). 1929.

17

The Reaction of Phenols With Tertiary Butyl Chloride*

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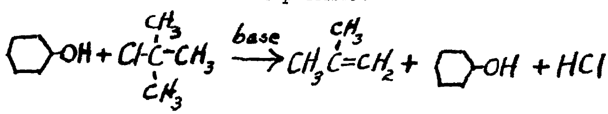
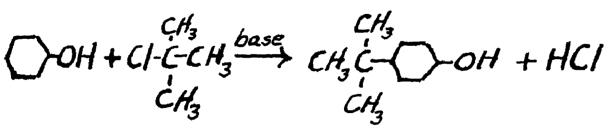
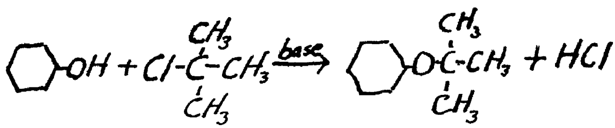
INTRODUCTION

The purpose of this investigation was to study the reaction between tertiary butyl chloride and phenolic compounds in the presence of a base, with particular attention to the possible formation of aryl tertiary butyl ethers. In such a mixture there are three main reactions possible:

I. 

II. 

III 

The first reaction is characterized by recovery of the unchanged phenolic compound and evolution of a gaseous olefine, the second by the formation of a phenolic compound, and the third by the formation of a high boiling, alkali insoluble ether. All three types of reaction have been reported in the literature, but no attempt has been made to ascertain whether or not the relative importance of these reactions is affected by the nature of the phenolic compound used.

Perhaps the most outstanding feature of the literature on this subject, aside from its scarcity, is its lack of variety in the compounds used. Only two articles were discovered which mentioned the reaction between tertiary butyl chloride and any phenolic compound other than phenol itself. In 1899 A. Gurewitsch (1) reported the formation of the readily decomposed mono-tertiary butyl ether of di-tertiary-butylresorcinol from the reaction of tertiary-butyl chloride with resorcinol in the presence of ferric chloride. Two years later, Speigel and Sabbath (2) described their failure to obtain any reaction other than the formation of isobutylene from the reaction between tertiary-butyl chloride and p-nitrophenol. Even the postassium salt of p-nitrophenol and tertiary-butyl chloride at 140° C and 20-24 atmospheres pressure gave only isobutylene and p-nitrophenol (Reaction I). The silver salt at room temperature and at atmospheric pressure reacted with the tertiary-butyl chloride in the same manner. Lewis (3) reported the formation of p-tertiary-butylphenol in fair yields along with a negligible quantity of a high boiling alkali-insoluble material when tertiary-butyl chloride was allowed to react with sodium phenate.

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*Contribution from the Bailey Chemical Laboratory.

Somewhat more recently the preparation of phenyl tertiary-butyl ether has been reported (4) according to reaction III and also from the reaction of phenol with isobutylene (5). In both cases the yields were very poor and the physical constants given for this ether differ rather widely. Smith (4) reported the ether to be a solid at room temperature, melting point unobtainable, and boiling point 102° whereas Edlund (5) described the same compound as a liquid at ordinary temperatures, boiling at 185°-186° C. An unpublished master's thesis, written in 1928 for the University of Chicago by W. G. Bechtel, described the preparation of tertiary-butyl p-tertiary-butylphenyl ether from the reaction between tertiary-butyl chloride and phenol in the presence of calcium carbonate (6). Apparently the initial reaction was the formation of p-tertiary-butylphenol followed by the formation of its tertiary-butyl ether.

EXPERIMENTAL PART

In many typical experiments 0.1 mole of alcohol or a phenolic compound and twelve grams (a slight excess of 0.1 mole) of tertiary-butyl chloride were dissolved in 100 ml. of absolute ethanol in which five grams of metallic sodium had previously been dissolved. The solution was refluxed for three hours and then poured into a large quantity of water. The oil separating was shaken with 5% sodium hydroxide solution, which brought about complete solution, indicating the products were entirely phenolic. Re-acidification of the solution, followed by separation and distillation of the precipitated oil, gave the starting phenolic compound (reaction I). Reactions of this type were carried out with phenol, p-chlorophenol, o-cresol, p-tertiary-amylphenol, hydroquinine mono-methyl ether, p-nitrophenol and thymol. P-cresol gave 5-10 ml. of a higher boiling alkali-soluble compound, probably 2-tertiary-butyl-4-methylphenol.

The effect of a more dilute solution of the base was tried, also. Using a 50% solution of ethanol and water as the solvent and using concentrations 0.2 to 0.6 molar with respect to sodium hydroxide and the phenolic compound the reaction was conducted with ortho and para-chloro-phenol and ortho and para-cresol. The results were the same as for the more concentrated solutions. In most of these experiments a small quantity of ethyl tertiary-butyl ether was obtained.

In a second group of experiments the effect of using a weaker base was studied and calcium carbonate was substituted for sodium ethoxide. Vigorous mechanical stirring was maintained in order to give good contact between the calcium carbonate and the rest of the reaction mixture. The general procedure follows:

One-fourth of a mole of the phenolic compound, 25 g. of tertiary-butyl chloride (a slight excess of ¼ mole), and 15 g. of calcium carbonate were stirred vigorously and refluxed for from three to four hours, or until the temperature of the vapors in the reaction flask reached 90 to 95° C. The reaction mixture was then washed into a two-liter round bottom flask with 150 ml. of 5% sodium hydroxide solution and steam distilled. A low bunsen flame was kept under the distilling flask throughout the distillation to prevent dilution of the alkali. The first forty or fifty ml. of distillate were then collected, and any oily layer was separated from the water. This oil was then washed with 10% sodium hydroxide solution and distilled. The phenolic products were recovered by acidifying the mixture in the distillation flask and

continuing the distillation in steam. By this procedure the following phenolic compounds gave only isobutylene and the unchanged phenol (Reaction I): o-chlorophenol, p-chlorophenol, o-cresol, p-methoxyphenol, p-nitrophenol and p-hydroxydiphenyl. Guaiacol (o-methoxyphenol) and p-hydroxybenzaldehyde gave no reaction at all; in fact, the tertiary-butyl chloride, as well as the phenolic material was unchanged. In this group of experiments three tertiary butyl ethers were obtained.

(1) The tertiary-butyl ether of p-chloro-m-cresol (2-chloro-5-methyl-phenol), bp. 265-270°/740 mm; molecular weight in benzene by the freezing point method 200 (Calc'd for $C_{11}H_{15}OCl$ mol. wt.=198). Analysis: Cl= 17.24; 17.21 Calc'd. Cl=17.85%. A purer sample could not be obtained.

(2) The tertiary-butyl ether of p-tertiary-amylphenol, bp 270-275°/740 mm.; molecular weight in benzene 215 (Calc'd for $C_{15}H_{24}O$ mol. wt.=220).

(3) The tertiary-butyl ether of p-tertiary-butylphenol, bp. 255-260/740 mm.

In a third set of experiments the base used was pyridine. The procedure followed was the same as that with calcium carbonate except that 20 ml. of pyridine was substituted for the 15 g. of calcium carbonate. Separation of the products was accomplished by pouring the reaction mixture into a large volume of water, followed by removal of the precipitated oil and thorough washing with 10% sodium hydroxide solution. In every case the alkali-insoluble material proved to be the unchanged halide, while the recovered phenolic material was found to be the original phenolic compound. Isobutylene was formed along with pyridine hydrochloride but no reaction producing any derivative at the phenolic compound could be detected in runs using o-cresol, phenol and p-tertiary-amylphenol.

SUMMARY

It has been shown that the most common reaction of phenolic compounds with tertiary-butyl chloride and a base results in the production of isbutylene and recovery of the phenolic material This is particularly true of p-nitrophenol. Substitution of the tertiary butyl group in the benzene ring ortho or para to the hydroxyl group occurred in numerous cases and the formation of a tertiary-butyl ether of the phenolic compound was observed only when several positions on the ring were occupied by substituting groups. Three such ethers were prepared.

LITERATURE CITED

1. Gurewitsch Ber. der Deut. Chem Gesel., *32*, 242 (1899).
2. Spiegel and Sabbath. Berichte der Deut Chem. Gesel. *34*, 1946 (1901).
3. Lewis. Journal of the Chem. Soc. *83*, 1946 (1903).
4. Smith. Journal of the A.C.S., *55*, 3718 (1933).
5. Likhosherstov and Arkhangel'skaya Jour. Gen Chem. (U.S.S.R.) *7*, 765 (1937).
6. Evans and Edlund. Industrial and Engineering Chemistry, *28*, 1186 (1936).
7. Bechtel. Master's Thesis, University of Chicago, 1928.

18

Reactions in Liquid Ammonia—I
Ammonolysis of Hexavalent Chromium Derivatives*

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Although recent researches have served to clarify, to a great extent, the chemistry of the aquo ammono sulfuric acids (1) and older researches to a somewhat lesser extent the chemistry of the aquo ammono phosphoric acids (2), the literature concerning the corresponding compounds of other acid-forming elements of periodic groups five and six remains incomplete, and, in many cases, contradictory.

This uncertainty is particularly true of the ammono derivatives of hexavalent chromium. In spite of a number of publications concerning the ammonolysis of various hexavalent chromium derivatives, there still has not been forthcoming a definite answer to the question, "Are aquo ammono chromic acids obtainable by direct reaction of hexavalent chromium compounds with anhydrous ammonia?" Several workers during the past seventy-five years have reported the preparation of salts of amidochromic and imidodichromic acids, (3, 4, 5) but several of their contemporaries (6, 7, 8) were unable to repeat their results. Since many of these early experiments involved ammonolytic reactions, followed by treatment of the ammonolytic product with water, it is almost certain that any ammono derivatives which might have formed were immediately hydrolyzed. Rosenheim and Jacobsohn later reported the preparation of ammonium imidochromate, $(NH_4)_2CrO_3NH$, along with some chromic oxide by the reaction of chromic anhydride with liquid ammonia in a sealed tube at room temperature (9). The analytical results reported, however, did not agree very well with the formula given.

The author hoped, in starting this problem, to be able to clarify somewhat the ambiguity in connection with the ammonolysis of hexavalent chromium compounds and to determine whether or not such reactions may be used for the preparation of aquo ammono chromates. It was decided, therefore, to study the reactions of chromic anhydride and of potassium chlorochromate with liquid ammonia under highly anhydrous conditions. Similar reactions had resulted in the formation of aquo ammono sulfates (1). The high oxidation potentials of these chromium compounds, however, caused complications, as is shown by succeeding data.

A series of reactions of chromic anhydride with an excess of anhydrous ammonia was carried out at –33°. On analyzing the ammonolytic product, it was found in every case that about one-fourth of the total chromium had been reduced to the trivalent state. When treated with liquid ammonia in a sealed tube at 0° under anhydrous conditions, chromic anhydride reacts so vigorously that, in some cases, at least, the reaction mixture inflames under the liquid ammonia. The presence of bright green particles, interspersed through the brown ammonolytic product, indicates considerable reduction.

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*Contribution from the Bailey Chemical Laboratory.

Experiments with potassium chlorochromate at –33° indicate that, in this case also, about one-fourth of the total chromium is reduced.

In order to determine whether or not chromic anhydride is reduced by ammonia at lower temperatures, the reaction of this compound with liquid ammonia, cooled to –80° by a dry ice acetone mixture, was carried out. It was found, however, that the amount of reduction was not decreased.

The fact that, with both chromic anhydride and potassium chlorochromate, the percentages of chromium reduced tend to approximate one-fourth of the total chromium is striking. In view of the preceding discussion and of the experimental details presented below, it seems that a very likely interpretation of these data is that there is formed a chromic aquo ammono chromate which precipitates from the liquid ammonia solution and stops further reduction. The exact formula for the product obtained is obscured by the uncertainty as to the degree of ammonation of the ions involved. The product shows a marked vapor pressure of ammonia and still loses weight even after standing in vacuo for more than a month. The simplest chromic aquo ammono chromate which may be formulated is $Cr^{III}(Cr^{VI}O_3NH_2)_3 \text{ x } NH_3$. A possible chromic imidodichromate which has the same ratio of Cr^{III} to $Cr.^{VI}$ may be formulated Cr_2^{III} $(Cr^{VI}O_3NHCr^{VI}O_3)_3 \text{ x } NH_3$.

In any case, in the light of these results, it is exceedingly doubtful that Rosenheim and Jacobsohn obtained any aquo-ammono chromate in any reasonable state of purity. Indeed, it is deemed exceedingly unlikely that such compounds are capable of preparation in the pure state by direct ammonolysis of hexavalent chromium compounds in liquid ammonia.

EXPERIMENTAL

Materials—The ammonia used in these studies was synthetic anhydrous ammonia, 99.95% pure. The ammonia was transferred to small steel cylinders in which there had been placed a few lumps of metallic sodium. After allowing time for the sodium to react, the hydrogen was valved off.

Chromic anhydride (c.p grade) was dried for 15 hours in an Aberhalden apparatus under vacuum over phosphorus pentoxide at the temperature of boiling bromobenzene. It was stored over phosphorus pentoxide. Before use, the product was analyzed for total chromium and for hexavalent chromium by the methods outlined below. Analysis: Calculated for CrO_3: Cr, 52.00. Found: Cr^{VI}, 51 55, 51 70; Cr (total), 51.90.

No satisfactory directions for the preparation of potassium chlorochromate were found in the literature. A method, based upon a reaction suggested by Geuther (10) was worked out. This method involves the action of chromyl chloride upon potassium chromate.

Preparation of chromyl chloride:—The chromyl chloride was prepared by a method employing a reaction reported by Low and Perkins (11). To a solution of 150 g. (1.5 moles) of chromic anhydride in 100 ml. of water was added 330 ml. of concentrated hydrochloric acid and the solution cooled to 0°. With mechanical stirring, 450 ml. of concentrated sulfuric acid was added, drop by drop, from a dropping funnel, regulating the rate of addition so that the temperature of the reaction mixture did not rise above 15° to 20°. The solution was then transferred to a separatory funnel and the lower layer (the chromyl chloride) drawn off into a glass stoppered container. Yield: 189 g.

(81% of theory). This product was used without further purification for the preparation of potassium chlorochromate.

Preparation of potassium chlorochromate:—A solution which was prepared by dissolving 75.0 g. (0.386 moles) of potassium chromate in 125 ml. of hot water was placed in a three-necked flask fitted with a mechanical stirrer, thermometer, dropping funnel, and a tube to carry away irritating vapors. While the solution was kept warm with a Bunsen flame, 86.0 g. (0.555 moles) of chromyl chloride was added drop by drop with continuous stirring. The rate of addition and the height of the flame were regulated so as to keep the temperature between 90° and 100°. The stirring was continued at this temperature for one hour. The solution was then placed in a covered beaker for crystallization. After standing eighteen hours, the red-orange crystals which had formed were removed by filtration with suction. The product was transferred to a porous plate, covered with a watch glass, and left overnight. Yield 109 g. (81% of theory based on the potassium chromate used). Analysis: Calculated for $KCrO_3Cl$: Cr, 29.79, Cl, 20.31; Found: Cr, 29.49, 29.47; Cl, 20.15, 20.20.

Method and Apparatus:—The method and apparatus used in carrying out the reactions at –33° were adapted, with certain modifications, from those used by Fernelius. The apparatus is shown in Figure I. Before beginning a run, the reaction chamber C, along with the surrounding Dewar flask D, was removed from the apparatus and thoroughly dried. The reaction chamber was then replaced. A glass rod, bent slightly at the end, had been sealed into the ground glass plug F and a small piece of rubber tubing fitted over the end of

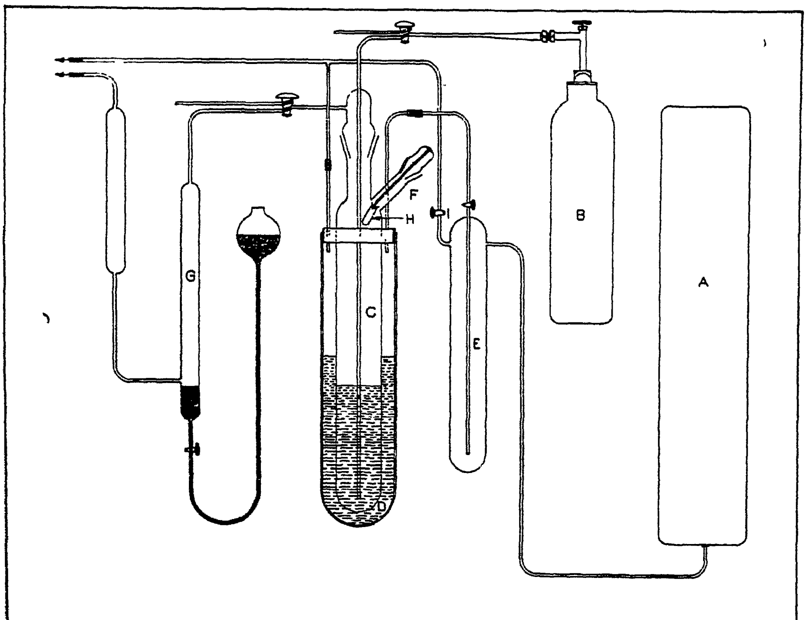

FIGURE I

the glass rod. A weighed quantity of the chromium compound used was placed in a small glass vial which was of such diameter that the rubber tubing which had been attached to the glass rod, formed an air-tight plug. With the vial in place at H, the glass plug F was fitted into the side arm of the reaction chamber. Pure anhydrous ammonia, which had stood over sodium, was passed from tank B through the apparatus for at least thirty minutes, thus removing all traces of air and moisture. The pressure was alternately increased and decreased by raising and lowering the mercury in G, thus flushing out the dead space in the apparatus such as in the side arm F. When the apparatus had been thoroughly flushed out, liquid ammonia, which had been drawn from tank A into E, was caused to flow into D. The pressure in the reaction chamber C was then increased by raising the level of the mercury in G, thus causing the ammonia gas from B to condense in the reaction chamber C. When sufficient ammonia had been condensed, the level of the mercury in G was lowered and the supply of ammonia gas from B shut off. The reaction was then initiated by rotating the glass plug F back and forth, thus pressing the vial at H against the walls of the reaction chamber and causing it to fall into the ammonia in C. From time to time, the reaction mixture was stirred by bubbling ammonia gas from B through the suspension. The reaction mixture was allowed to stand until all the excess ammonia had evaporated from C and D (usually over 24 hrs.). The solid residue was then dissolved in dilute (10%) sulfuric acid and the solution analyzed for total chromium and for hexavalent chromium by the method described below.

Method of Analysis:—Hexavalent chromium was determined by diluting the acid solution of the product to volume, taking an aliquot portion, adding excess ferrous sulfate solution, and titrating with standard chromate solution. Total chromium was determined in the same manner, except that the sample solution was boiled with ammonium persulfate prior to the addition of the ferrous sulfate.

Reaction of Chromic Anhydride with Liquid Ammonia at −33°:—Weighed samples of chromic anhydride in thin glass vials, which had been scored with a glass file to facilitate their cracking, were introduced into liquid ammonia according to the method described above. The chromic anhydride apparently reacts only slowly. At first, the supernatant liquid assumes a clear yellow-orange tint. In a short time, a yellow-tan precipitate begins to form. Gradually, the dark-colored solid which is observed when the CrO_3 is first added is converted to the light yellow-tan precipitate which remains after all the excess ammonia has evaporated. The product thus obtained shows a marked vapor pressure of ammonia which persists even after the product has stood in vacuo for more than a month. It was thus impossible to get significant nitrogen analyses. The products were analyzed for total chromium and for hexavalent chromium by the method outlined above. The results of a series of these experiments are summarized in Table I.

Reaction of Potassium Chlorochromate with Liquid Ammonia at −33°. These experiments were carried out in the same manner as those with chromic anhydride. When the potassium chlorochromate is introduced into the liquid ammonia, there forms immediately a dark, reddish-brown precipitate (similar in color to hydrated ferric oxide). When all the excess ammonia has evaporated, there remains a light yellow-tan product very similar in appearance to

that obtained by the chromic anhydride reaction. This product was dissolved in dilute sulfuric acid and analyzed as described above. The results of a series of such experiments are listed in Table II.

Reaction of Chromic Anhydride with Liquid Ammonia at 0°. Two fifteen-inch lengths of thirteen millimeter pyrex tubing were connected by means of a large bore stop-cock. The end of one of these tubes was sealed off. By use of a cooling mixture of dry ice and acetone, an excess of anhydrous ammonia was condensed into this part of the apparatus. The stopcock was then closed and a weighed quantity of chromic anhydride introduced into the other end of the apparatus and that end sealed off. The whole apparatus was then placed in an ice bath and the temperature allowed to come to 0°. The stopcock was then opened and the ammonia mixed with the chromic anhydride. The reaction which takes place under these conditions is exceedingly vigorous and in one case the reaction mixture actually inflamed under the excess liquid ammonia. The solid formed is not homogeneous, and, after opening the tube and allowing the excess ammonia to evaporate, there remains a yellow-tan solid interspersed with some bright green lumps (presumably chromic oxide) indicating considerable reduction. The extreme vigor of the reaction made it seem inadvisable to study the reaction further under these conditions.

TABLE I—Reaction of CrO_3 With Liquid Ammonia at –33° C

		Analysis:			
Moles CrO_3	Moles NH_3	Total Moles Cr	Moles Cr^{VI}	Moles Cr reduced	Moles % reduced
0 01266	1 8	0.01258	0.00921	0.00337	26.8
0.01242	1.8	0.01240	0.00914	0.00326	26 3
0.01225	1.8	0.01218	0 00942	0.00276	22 6
0 01198	1.8	0.01192	0.00888	0.00304	25.5
0 01230	1 8	0 01229	0.00902	0.00327	26.6
0.01189	1.8	0.01177	0.00887	0 00290	24.7
0.01120	1.8	0.01098	0 00802	0.00296	27.0
0 01571	1.8	0.01565	0.01200	0.00365	23.3
0 01341	1.8	0.01340	0.00973	0 00367	27 4
0.01406	1.8	0.01402	0.01037	0.00365	26.0

TABLE II—Reaction of $KCrO_3Cl$ With Liquid Ammonia at –33° C

		Analysis:			
Moles $KCrO_3Cl$	Moles NH_3	Total Moles Cr	Moles Cr^{VI}	Moles Cr reduced	Moles % reduced
0.00212	1.8	0.00208	0.00159	0.00049	23 6
0 00190	1 8	0.00186	0.00136	0 00050	26.9
0 00226	1.8	0.00222	0.00160	0 00062	27 9
0 00244	1.8	0.00241	0 00177	0.00064	26.6

SUMMARY

1. Detailed study of the reactions of chromic anhydride and potassium chlorochromate with liquid ammonia at –33° indicates that aquo ammono chromates are not obtained in any reasonable degree of purity since approximately one-fourth of the chromium is reduced by the ammonia.

2. The fact that approximately one-fourth of the chromium is reduced may indicate a tendency toward the formation of some sort of chromic aquo ammono chromate which precipitates and inhibits further reduction.

3. Satisfactory procedures for the preparation of potassium chlorochromate and of chromyl chloride have been developed.

LITERATURE CITED

1. Audrieth, Sveda, Sisler, and Butler. Chem. Rev., *26,* 49 (1940).
2. Franklin. "Nitrogen System of Compounds," Reinhold Publishing Corp. New York, N. Y., 1935, Chap XVI.
3. Lowenthal. Z. anorg. Chem., *6,* 355 (1894).
4. Ohly. Chemical News, *80,* 134 (1899).
5. Heintze. J. prakt. Chem., (2), *4,* 214 (1871).
6. Wyrouboff. Bull. Soc. Chem. (3), *11,* 845 (1894).
7. Meyer and Best. Z. anorg Chem., *22,* 197 (1900).
8. Werner and Klein. Z. anorg. Chem., *9,* 291 (1895).
9. Rosenheim and Jacobsohn. Z. anorg. Chem., *50,* 297 (1906).
10. Geuther. Ann. chim. phys., (2), *52,* 267 (1833).
11. Low and Perkins. J. Chem Soc., *91,* 191 (1907).

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The Electrodeposition of Silver From Solutions of Silver Nitrate in the Presence of Wetting Agents*

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The electrolytic deposition of silver from a neutral solution of silver nitrate gives a deposit which is rough, non-adherent and of large-grained crystalline form. In industry, whenever a smooth, firm, uniform, silver deposit is desired, the complex silver cyanide bath is almost always used. The film of deposited silver is flat white in appearance, but assumes its characteristic metallic luster when it is burnished. Although the cyanide bath gives satisfactory silver deposits, it would be desirable to find a substitute, because the cyanides are such violent poisons.

It has been found by various investigators (1) (2) (3) (4) (5), that the presence of many impurities or "addition agents", in the electrolyte, have an effect upon the form of the deposit. The theory of addition agent action has been discussed in the literature (6) (7). On the whole, the progress along this line has been largely empirical, as illustrated by the addition to plating baths of substances whose functions are not understood or predictable, although they may lead to desired results.

Briefly, if any substance is added to the electrolyte, the ions migrate to the electrodes and if not discharged, they accumulate at the cathode and will thus alter the environment from which the simple ions are being discharged. Other effects which are responsible for the various types of deposits would be adsorption and other inter-facial tension effects at the cathode, changes in conductivity due to the presence of other ions, and electrode reactions other than the simple discharge of silver ion.

Taft and Horsley (5), carried on investigations with 169 addition agents (organic and inorganic) in an attempt to determine a relationship between the nature of the addition agent and the mass and form of the silver deposit. These deposits were classified as Control (no effect), Intermediate, Fine (macroscopically much smoother than the deposits in the control baths), Abnormal, and Striated. The deposits were weighed and analyzed for silver. They found that colloids of high molecular weight (above 250) produced abnormal or striated deposits. Smoother fine crystalline deposits resulted upon addition of certain inorganic salts. The lower fatty acids (formic, acetic and proprionic) did not produce a fine-grained deposit. Taft and Hodge (8) and Taft and Lutness (9) further studied addition agent action for silver deposition, at various conditions of temperature, concentration of addition agent, and current density.

This study is an extension of the above investigations and is an attempt to determine the effect of various "wetting agents" upon the form of electrolytically deposited silver Extensive lists of wetting agents manufactured in America and commercially available, are to be found in the literature (10) (11).

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*Contribution from the Bailey Chemical Laboratory.

The term "wetting agent", has come into use as a general description for compounds which in small quantities modify the properties of a system by adsorption at an interface so that spreading of liquid over solid takes place more readily. Such compounds—when used for special purposes—have also been called dispersants, penetrants, detergents, foamants, emulsification agents, and surface-active agents The theoretical considerations of wetting agents are discussed in the literature by Adam (12), Bartell (13) and Hartshorn (14). Usually it is assumed that a monomolecular film is adsorbed and oriented at an interface, the allignment taking place in such a way as to cause like molecular groups to be in contact, thereby producing a marked transition in the properties at the interface. The chemistry of wetting agents is concerned with the magnitude of change of free surface energy which occurs as a surface environment becomes altered. Separate phases possess interfacial energy and are thus capable of undergoing certain changes, or of doing certain work. The molecules of a wetting agent thus orient themselves at an interface so that the interfacial tension, or the free energy at the interface is lowered.

The use of wetting agents in the electrodeposition of nickel has already been established. They were first introduced as anti-pitting agents. Hartshorn (14), has discussed the mechanism of wetting, and the requisites of wetting agents to be used in plating solutions. According to Davis (15), the lowering of the interfacial tension between the cathode and the electrolyte, causes the hydrogen bubbles which would otherwise collect at the cathode, to be forced to the surface of the bath, thus eliminating pitting in nickel deposits. However, with regard to the use of wetting agents for nickel depositions, there are very few which meet the requirements for bright nickel plating. Only the normal straight chain alcohol sulfates and some of the alkyl-substituted aryl sulfonates have been used to any appreciable extent commercially (7). P. R. Pine (7) believes this effect to be due to the relative ease of upsetting the delicately balanced equilibria of the colloidal particles in their function as control agents for crystal growth, which may be brought about by condensation or polymerization of the wetting agent in the bath

Since liberation of hydrogen does not accompany the deposition of silver under normal conditions, any effect of wetting agents upon the form of the deposited metal would doubtless be due solely to the lowering of the interfacial tension between electrode and solution with attendant positive adsorption. A lowering of interfacial tension would thus tend to produce a larger surface of contact of silver and solution (and therefore a finer crystalline deposit) but would probably be accompanied by inclusion of wetting agent due to positive adsorption. This inclusion of foreign substance would tend in itself to modify the properties of the deposited metal both by changing the crystal form[1] and by altering the mechanical properties of the deposit, *i e* render it more brittle (or less brittle), more adherent (or less adherent), etc. The effect of any given wetting agent would therefore be the result of all these factors, and hence wetting agents in general could be expected to produce many diverse phenomena.

Search of the literature failed to show that any work had been done on the electrodeposition of silver in the presence of wetting agents.

[1]No change in crystal *type* is produced; addition agents, in general, may favor the growth of one crystal axis over the others, producing in some cases extraordinary results.

In this work, representative wetting agents were selected from each of the various types available. The form and mass of silver deposits from solutions of silver nitrate in the presence of these wetting agents was determined.

EXPERIMENTAL PROCEDURE

The experimental procedure for this study was essentially the same as that adopted by Taft and Horsley (5). The conditions imposed in their investigation were: concentration of agent studied 0.1%, current density 0.50 amps/dm^2, temperature 30° C, and concentration of silver nitrate 0.25 Molar. These conditions were imposed upon the trials reported in part A of this study.

The electrolyses were carried out in a series of twelve cells, submerged nearly to the rim in a constant temperature bath. The cells consisted of 100 ml beakers filled with about 75 ml of electrolyte. A special rack facilitated the suspension of the cells in the constant temperature bath. A support, supplied with inch clamps and wire connections in series, held the electrodes so that they fitted properly into the respective cells.

The cathodes were platinum squares 2.5 x 2.5 cm (6.25 cm^2), provided with platinum stems. They were cleaned with dilute nitric acid and distilled water, then dipped into methyl alcohol, the methyl alcohol burned off and the electrode heated to redness for several seconds. This treatment was followed by weighing on the analytical balance.

The anodes consisted of solid silver bars of high purity.

The electrodes were placed approximately 3.5 cm apart in the cells A 110 D C. line furnished the current for electrolysis. Adjustment of the current was made by means of a varying resistance and ammeter.

The current density employed, was 0.50 amps/dm^2. In order to maintain convenient masses of deposits of about 0.2000 grams, a current of 0.03125 amps was run through the cells for 100 minutes. The temperature of the bath was kept at 30° C.

Following electrolysis, the cathodes were removed from the cells and washed thoroughly with distilled water. Loose, fluffy and spongy deposits were handled as gently as possible and washed several times, by carefully dipping the electrodes into a beaker of distilled water. Then the deposits were allowed to dry for at least one hour, and weighed to determine the mass of the deposit.

All determinations were run in duplicate. In each batch of twelve cells there were two controls (cells containing 0.25 M $Ag\ NO_3$ and no wetting agent).

For purposes of comparison, the masses of all deposits were calculated to a standard mass of 0.2000 grams in the controls This computation was made in the following manner:

$$\text{Computed mass} = \frac{\text{Average mass of duplicate deposits}}{\text{Average mass of control deposits}} \times 0.2000$$

Much difficulty was encountered in making up the electrolytes, since most of the wetting agents formed precipitates with the silver nitrate solution. Since extract of filter paper produces a deposit different from that of the control (1), it was necessary to filter off the precipitates by some other means. The solutions which contained precipitates, were filtered through sintered glass filters using the water pump and filter flask. Out of eighty-four wetting agents, only eight formed no precipitate with 0.25 M $AgNO_3$. These were, Drene, Aerosol 1B, Aerosol OT Dry, Tris (hydroxymethyl) amino methane, Cue Liquid Den-

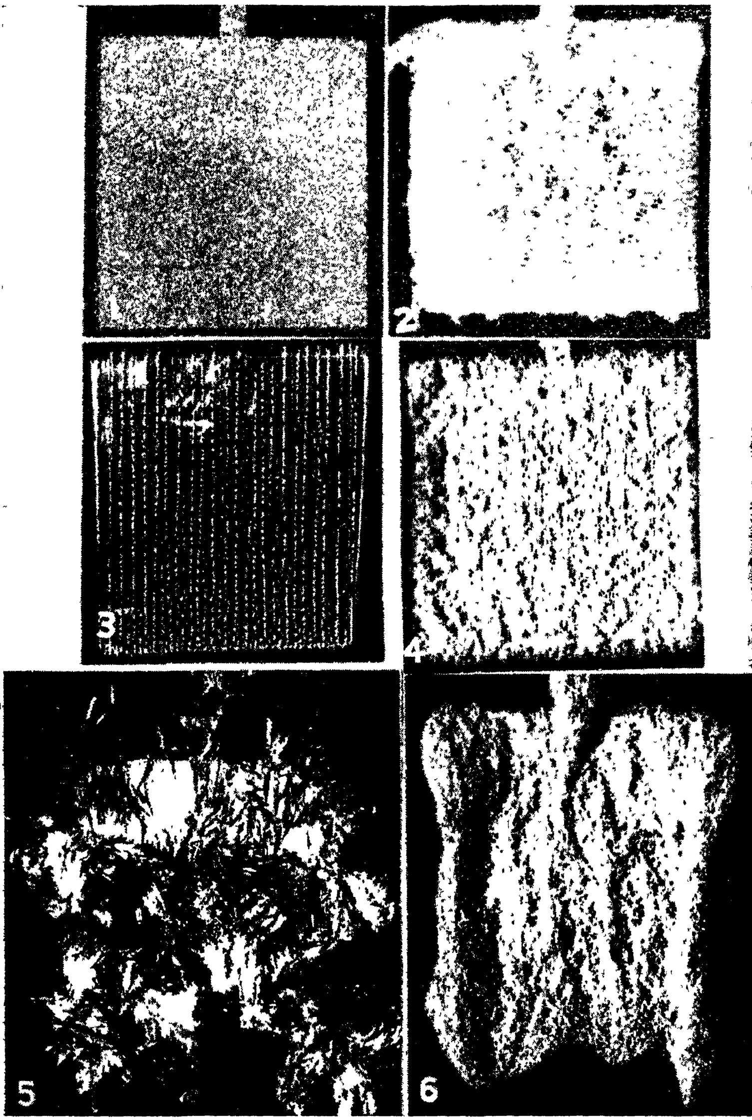

FIGURE 1 Typical electrodeposits of silver in the presence of wetting agents, x 1½. 1. Control; 2. Aerosol OT; 3. Aerosol AY; 4. Glyceryl monolaurate (alcohol derivative); 5. Nekal A (a sulfonate); 6. Tergital Penetrant 7 (a sulfate).

tifrice, Triton NE, Emulpho ELA and pyridine. Of those solutions which contained precipitates, fifty came through the filter clear, while twenty-four of them retained a permanent turbidity, even after filtration. Upon standing for a few days some solutions which had been clear, slowly precipitated again. Upon long standing, many of the solutions had fine sedimentary precipitates in the bottom of their containers, or else formed a mirror of metallic silver on the inside of the container indicating reduction of silver. The sintered glass filters were cleaned with hot concentrated nitric acid, and distilled water.

Each deposit was examined macroscopically and microscopically and carefully compared with the control deposits. When there was any question about a deposit, duplicate samples were rerun. Special attention was given to the general form of the deposit, size of the crystals, form of crystals, color of deposit, discoloration, adherency, coverage and throwing power. Representative deposits of all but the smoother fine deposits were photographed and have been included in the experimental data

The data for each wetting agent includes the weight of the deposit where possible, the condition of the solution used as electrolyte (either clear or turbid), and notes on the deposits.

In Part B of this work, the investigation was further extended by varying the concentration of the wetting agent, current density and temperature, upon several selected wetting agents. Concentration of wetting agent was varied from 0.0001% to 10%; current densities varied from 0 25 to 2.0 amps/dm^2; depositions were run at temperatures of 45°, 30° and 0° C. Two controls were run with each batch of depositions, but duplicate samples of all solutions and weighing of the cathode before and after electrolysis, was omitted. The electrolyses were run for lengths of time such as to give a deposit of about 0.2000 grams, *i.e.* 0.01562 amps for 200 minutes (C D. = 0.25), 0.3125 amps for 100 minutes (C.D. = 0.50), 0.0625 amps for 50 minutes (C.D. = 1.0), 0.09375 amps for 33 minutes (C.D. = 1.5), 0.1250 amps for 25 minutes (C.D. = 2.0).

In the data will be found listed all the conditions at which the electrolyses were carried out. All comparisons to the control deposits refer to the controls at the corresponding current density and temperature. Reference control data at various conditions appears in the data of Part B.

FATTY ACID SALTS AND SOAPS

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
1.	Ammonium Laurate	0.2000	clear	Finer than control, barely visible striae, good adherence and coverage.
2.	Ammonium Stearate	0.2004	clear	Finer than control, no striae, good adherence and coverage.
3.	Potassium Oleo-abietate (Miscibol)	0.2025	clear	Pronounced well built up striae, tan discoloration.
4.	Ivory Soap	0.1997	clear	Same size crystals as control, more adherent, striae.
5.	Oxydol	0.1990	clear	Same size crystals as control, striae.
6.	Rinso	0.2030	clear	Coarser than control, no striae, rubs off easily.
7.	Duz	0 2003	clear	Control, but better coverage.
8.	T··ox (A cleaning and scouring soap)	0.2002	clear	Same as (7).
9.	Cal soap (A drycleaning soap)	0.2002	clear	Control.
10.	Sizeoff (A desizer for dry cleaning	0.2007	clear	Extensive treeing in the form of flakes
11.	William's Shave Cream	0.2012	clear	Control, but slightly striated.
12.	Mennen Brushless Shave Cream	0.2005	clear	Slightly finer than control.
13.	Molle Brushless Shave Cream	0.2013	clear	Same as (12).

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
14.	Cue Liquid Dentrifice	0.2002	clear	Tan colored, loosely adherent fuzzy deposit, striae, edges built up.
15	Fitch Shampoo	0.2004	clear	Larger crystals than control, striae.

DISCUSSION

Ammonium laurate and ammonium stearate in this group produced deposits finer than that of the control.

The following soaps: Oxydol, Rinso, Ivory Soap, Duz, Triox, Cal-soap; three shaving creams (11,) (12) and (13); and Fitch Shampoo, gave deposits much like the control. In several of these, deposits (4), (7) and (8), the coverage and adherency was better than that of the control.

Cue, a liquid dentifrice, was one of the few wetting agents of the 84 wetting agents tried, which did not give a precipitate with 0.25 M $AgNO_3$ solutions, even on long standing. It gave the most non-adherent and fuzzy deposit of this group.

While most of the masses of deposits were not far from that of the control, Miscibol and Rinso were greater by 0.0030 grams and 0.0025 grams, respectively.

Further experimentation not listed in the data, consisted in deposition from ammonium laurate solutions, while stirring the solution with an ordinary L type glass stirrer and motor, keeping other conditions the same as before.

Ammonium laurate was chosen, because it gave the type of well adhering deposit desired. It was thought that the stirring of the solution might cause the striae to disappear. The resulting deposit was somewhat smoother than (1), and had caused the vertical striae to disappear. However, sidewise striae, similar to finger-marks now appeared on the deposit.

Revolving the entire cathode was also tried for ammonium laurate solutions. For this, the platinum cathodes were bent into a circular form of approximately one cm. diameter, and the deposition carried on while the cathodes were revolving in the solution at a rate of five revolutions per second. The resulting deposit was again smoother than (1), and the striae had disappeared, but sidewise finger-marks appeared again. There was also some treeing.

As a means of comparison, controls were run, both with stirring of the solution, and revolving of the cathods. No difference from the ordinary controls was observed in either case.

THE SULFONATES

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
1.	Sodium alkly naphthalene sulfonate (Alkanol B)	0.2236	Turbid	Spongy tan deposit about 1 cm deep on the electrode, collapses on removal from bath, very poor adherence.
2.	Sodium alkyl naphthalene sulfonate (Alkanol SA)	0.2315	Turbid	Same as (1), back side covered with flat shiny crystals, giving the appearance of silver foil.
3.	Sodium alkyl naphthalene sulfonate plus a Fungicide (Alkanol HG)	.. ..	clear	Tan, striated, not spongy, long trees which fell off.
4.	Sodium tetrahydro naphthalene sulfonate (Alkanol S)	0.2013	clear	Control.
5.	Sodium alkyl naphthalene sulfonate (Nekal A)	. ...	Turbid	Very large flakes covering the electrode to a depth of 1 cm, very poor adherence.
6.	? (Nekal AEMA)	0.2040	clear	Very well adhering, gold and dull grey striae, discoloration, some bare spots, slight treeing.

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
7.	Sodium sulfonate of petroleum hydrocarbons (Ultra wet)	0.2099	clear	Dirty grey discoloration, striae, somewhat fuzzy, poor adherence.
8.	Sodium sulfonates in a paraffin oil (Stanco Soap Product 302)	0.2077	....	Same type as (7), better coverage.
9.	Sodium sulfonates of petroleum (Stanco Soap Product 702)	....	Turbid	Silvery loosely adhering crystals, striae, treeing, collapses on removal from bath.
10.	Sodium alkyl naphthalene sulfonate (Neomerpin N)	0.2174	clear	Large silvery crystals which look like silver foil, poor adherence, some bare exposed platinum.
11.	Sodium alkyl phenylene sulfonate (Invadine B)	0.1998	Turbid	Grey discoloration, striae, treeing, loosely adherent, bare exposed platinum.
12	Sodium alkyl naphthalene sulfonate (Invadine C)	0.2020	clear	Much finer striae, less discoloration, more adherent, less treeing than (11).
13.	Sodium alkyl naphthalene sulfonate (Invadine N)	0.2009	clear	Grey discoloration, fine crystals, good adherence, striae.
14.	Salt of substituted aromatic sulfonic acid. (neutral) (Santomerse 1)	....	Turbid	Spongy, fuzzy, dark tan, poorly adhering deposit, rubs off as a fine powder.
15.	Same (alkaline) (Santomerse 2)	....	Turbid	Spongy, fuzzy, tan crystalline type, poor adherence, striae.
16.	Same (neutral) (Santomerse 3)	....	Turbid	Same as (14).
17.	Same (neutral) (Santomerse D)	0.2295	Turbid	Spongy, edges well built up, poor adherence, dark discoloration.
18.	Sodium monosulfonate of monobutyl phenyl phenol (Areskap)	0.2118	clear	Extensive treeing at the surface of the solution, poor adherence, striae, color of control
19.	Sodium monosulfonate of monobutyl diphenyl (Aresket)	0.2148	clear	Very spongy, poor adherence, tan colored. The deposit stands off from the electrode 1.5 cm, and collapses on removal from bath
20.	Sodium disulfonate of dibutyl phenyl phenol (Aresklene)	0.2012	clear	Spongy with flat crystals in the form of a crisscross network, poor adherence, color of control.
21.	Sodium isopropyl naphthalene sulfonate (Aerosol OS)	....	Turbid	Completely black with dark globular mud-like blobs in striae formation, extensive treeing, poor adherence
22.	1 Naphthyl amine 4-Sulfonic acid	0.2004	Turbid	Long flat shiny crystals, treeing.

DISCUSSION

The wetting agents of the sodium sulfonate group result from the addition of a hydrocarbon side chain and a sodium sulfonate group to an aromatic nucleus, to form alkyl aryl sulfonates. The aromatic nucleus is predominantly that of benzene, but naphthalene, diphenyl and hydrogenated cyclic compounds also are important.

It should be pointed out first of all, that there is the possibility that some of the wetting agents in this group of sulfonates should be placed among the sulfates, and vice versa. This is due to the fact that commercial nomenclature does often not clearly distinguish between the two.

Twenty-two different sulfonates were tried. None of these solutions gave a deposit finer than the control. Alkanol S (a hydrogenated aromatic derivative) gave the best deposit. It was not better than the control.

In general, the deposits of this group were characterized by spongy non-adherent tan colored deposits, or deposits with large flat, shiny, loosely-held crystals, which were built up on the electrode surface to depths of one cm. or more, and which collapsed on removal from the bath. Only Alkanol S, Nekal AEMA, and Invadine N were at all adherent.

Poor adherence made it difficult to obtain reliable data on the masses of the deposits. Where weighing was possible, the deposits weighed more than the control deposit (0.2000 grams). On the average, the mass of the deposits over

that of the control was five per cent. In the case of Alkanol SA, the weight of the deposit was greater by more than 15% of the control.

Further experimentation, not listed in the data, consisted in increasing the current density to 1 amp./dm² (*i.e.* twice the C.D. used previously), in the deposition from solutions of Invadine B, C, and N, (non-spongy, striated deposits of this group). The only difference noted, was an increase in striation tendency and treeing, as would be expected.

THE AEROSOLS

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
1.	Dibutyl ester of sodium sulfosuccinate (Aerosol 1B)	0.2004	clear	Fairly smooth, very fine striae, delicate fine trees.
2.	Diamyl ester of sodium sulfosuccinate (Aerosol AY)	0.2030	Turbid	Striated in globular form, dull white to black discoloration, some treeing.
3.	Dihexyl ester of sodium sulfosuccinate (Aerosol MA)	.. ..	Turbid	Striated and treeing across to the anode; shorted out after 60 minutes of plating time.
4.	Dioctyl ester of sodium sulfosuccinate (Aerosol OT Dry)	0.2058	clear	Spongy loose tan colored, poorly adhering deposit.
5.	Sulfonated ester of dicarboxylicacid (Betasol)	.. ..	Turbid	Spongy, loose, dirty grey discoloration, striae, rubs off easily.

DISCUSSION

From among the group of wetting agents of the esters of sodium sulfosuccinate, which have the general structure $\begin{array}{l} CH_2COO(CH_2)nCH_3 \\ \vert \\ CH(SO_3Na)(CH_2)mCH_3 \end{array}$ the butyl, the amyl, the hexyl, and the octyl esters were chosen. These differ only in the number of CH_2 groups in the non-polar end of the molecule, and have n equal to m.

It should be expected, that there might be some orderly variation of deposit type in proceeding from the amyl to the octyl ester. Each of the deposits, however, is of quite a different type. It is also significant that Aerosol OT, whose solution has the lowest surface tension of this group, should give the poorest deposit.

Notice, that in going from the amyl to the octyl ester, there is the following change: fine delicate striae (1), less adherent dirty striae (2), less adherent and treed deposit (3), spongy very poor adherent deposit (4).

It is seen also, that there is an increase in the mass of deposit, as compared to the control, in going from the amyl to the octyl ester.

THE IGEPONS

Ref. No	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
1.	Sodium fatty acid ester sulfonate $C_{17}H_{33}COOC_2H_4SO_3Na$ (Arctic Syntex A)	0 1990	Turbid	Well defined, highly built up striae, poor adherence, rubs off to tan powder.
2.	Sodium fatty acid ester sulfate $RCOO(CH_2)nSO_4Na$ (Wetanol)	0 2009	Turbid	Well built up blobs aligned in the form of striae, much bare exposed platinum
3.	$CH_3(CH_2)_{10}COOCH_2$–$CHOHCH_2SO_4Na$ (Arctic Syntex M)	0.1994	clear	Flat crystals, spongy fuzzy deposit, tan color, edges built up.
4.	Sodium fatty acid amido sulfonate $C_{17}H_{33}CONHC_2H_4SO_3Na$ (Arctic Syntex T)	.. ..	Turbid	Dark striae wide apart, much bare exposed platinum, rubs off easily.
5.	$C_{17}H_{33}CONCH_3C_2H_4SO_3Na$ (Igepon T)	.. ..	Turbid	Fuzzy striae, poor adherence, treeing.

DISCUSSION

Here again, as in the experiments with the aerosols, there is a wide variance in the type of deposit for members of the same group.

THE SULFATES

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
1.	Sodium lauryl sulfate (Dreft)	.. ..	Turbid	Very poorly adhering, fuzzy, rubs off easily, tan colored.
2.	Sodium lauryl sulfate (technical (Dryus)	.. ..	Turbid	Same as (1).
3.	Sodium lauryl sulfate (technical (Duponol WA)	.. ..	Turbid	Extremely poor adherence, large flat crystals.
4.	Sodium oleyl sulfate (Duponol LS)	0.1967	Turbid	Somewhat spongy, poor adherence, striae, tan colored.
5.	Long-chain alcohol sulfate (Duponol 80)	0.1994	clear	Same as control, but slight striation tendency.
6.	Long-chain alcohol sulfate (Duponol L-144)	.. ..	clear	Fuzzy tan deposit, peculiar treeing in the form of flat crystals, poor adherence.
7.	Sodium oleyl sulfate, plus a synthetic resinous sticker (Grasselli Spreader Sticker)	0.1982	clear	Fuzzy grey deposit, striae, rubs off to a powder.
8.	An alkyl sulfate (Du Pont In-3622)	.. ..	clear	Fuzzy spongy dark tan deposit, very poor adherence, striae.
9.	Triethanolamine lauryl sulfate (Drene)	.. ..	clear	Same as (1).
10.	$C_4H_9CH(C_2H_5)CH_2SO_4Na$ (Tergitol Penetrant 08)	0.2000	clear	Somewhat finer than control, coverage is poorer than control.
11.	$C_4H_9CH(C_2H_5)C_2H_4CHCH_2$–$CH(CH_3)_2SO_4Na$ (Tergitol Penetrant 4)	.. ..	clear	Smooth base covered with silken fine tan trees, striae.
12.	$C_4H_9CH(C_2H_5)C_2H_4CHC_2H_4$–$CH(C_2H_5)_2SO_4Na$ (Tergitol Penetrant 7)	0.2092	clear	Spongy deposit, loosely adhering, tan colored.

DISCUSSION

The sulfates (1-9) of this group are very much alike in composition. Except for Duponol 80 (an alcohol sulfate), the deposits from these were either poorly adherent tan colored fuzzy deposits, or deposits with large flat non-adherent crystals.

The Tergitol Penetrants (10), (11) and (12) are sodium sulfates of the higher synthetic secondary alcohols. Tergitol 08 (10), the smallest and least branched molecule of these three, gave a deposit finer than the control, with, however, poorer coverage. Tergitol Penetrant 4 (11), a larger and more branched molecule, gave a very peculiar deposit, with extremely fine silken trees. Tergitol Penetrant 7 (12), whose molecule contains four more carbons than (11), gave a spongy deposit.

Thus, from this group of twelve sulfates, not one gave a deposit better than that of the control. From what has been said in the discussion on the sulfonates, there seems to be little difference in the type of deposit of the sulfates and the sulfonates. Their general characteristics are the same.

ALCOHOL AND POLYALCOHOL DERIVATIVES

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
1.	Fatty acid salt of 2-Amino-2-Me-1-Propanol	0 2014	clear	Finer around the edges than control, center of the electrode contains coarser crystals, very well adhering, somewhat striated, color of control.
2.	Fatty acid salt of 2-Amino-2-Me-1, 3-Propanediol	0 2013	clear	Well built up striae, well adhering, much bare platinum exposed, tan color.
3.	Tris (hydroxymethyl) amino methane	0.2004	clear	Much finer than control, dull white, good coverage, no striae, no treeing.
4.	Condensation product of ethylene oxide and an organic acid (Emulphor ELA)	0 2006	clear	Well defined extremely fine striae, edges built up, fair adherence.
5.	Same (Emulphor AG Oil)	0.2008	clear	Larger crystals than control, striae, very poor coverage.
6.	Diglycol Laurate	.. ..	clear	Larger crystals than control, poor adherence, striae, bare areas of platinum, tan color.

Ref. No.	Wetting Agent	Wt. of Deposit (gr)	Solution	Notes on Deposits
7.	Diglycol Stearate	0 2000	clear	Somewhat finer than control, bare areas of exposed platinum, good adherence, no striae, color of control.
8.	Diglycol Oleate	0.1996	clear	Fuzzy, tan, striated deposit, poor adherence.
9.	Glyceryl Monolaurate	0 1996	clear	Much more fuzzy and poorer adherence than (8).
10	Glyceryl Monostearate	0 2002	clear	Very delicate fine-crystallined striae, very well adhering, color of control.
11	Glyceryl Monoricinoleate	0.1997	clear	Larger crystals than control, striae, poor adherence, tan colored.
12.	Sulfated glyceryl amide (Alframine DCA)	0.2001	Turbid	Large silvery flat crystals, striae, poor adherence
13.	Ammostearin	0.2000	clear	Well adhering striated deposit, tan color, crystals larger than control.
14.	Sorbitan Monolaurate (Atlast G-759)	0.2038	clear	Somewhat fuzzy, somewhat crystalline, striae, tan color
15.	Mannitan Monolaurate (Atlas G-772)	0.1999	clear	Same as (14).
16.	Sorbitan Monooleate (Atlas G-944)	0.2002	clear	Somewhat coarser than control, very close striae.

DISCUSSION

This classification of alcohols is somewhat arbitrary, but it does provide a place for some of these wetting agents which would be difficult to classify at all.

This group of wetting agents is distinctive in that its members are non-ionic, or nearly so.

Two of the wetting agents in this group, Tris (hydroxymethyl) amino methane, and Emulphor ELA, gave no precipitate with 0.25 M $AgNO_3$ solution. All the rest of them gave precipitates. On filtration of these solutions through sintered glass filters, all but Alframine DCA, gave clear solutions. Only three solutions of this group (1), (3) and (7) gave deposits finer than the control. Tris (hydroxymethyl) amino methane (3) was the outstanding fine smooth dull white deposit. This deposit showed no tendency towards striation, or treeing.

All of the deposits except (3) and (7) were striated.

In general, this entire group was more adherent and showed less treeing than other groups. Where fuzzy non-adherent deposits were obtained as in (8), (9), (11), (12), (14), and (15), the fuzziness was much less pronounced than in such groups as the sulfonates and sulfates. Spongy, thick deposits were altogether absent.

With the exception of Atlas G-759 (14), the masses of deposits did not differ very radically from the mass of the control.

ETHER DERIVATIVES

Ref. No.	Wetting Agent	Wt. of Deposit (grs)	Solution	Notes on Deposits
1.	Sodium alkyl aryl ether sulfate (Triton W-30)	.. ..	Turbid	Fuzzy grey striated deposit, very poor adherence, rubs off to a powder.
2.	Sodium alkyl aryl polyether sulfonate (Triton 720)	.. ..	Turbid	Same as (1), except less tendency towards striation
3	Amine salt of alkyl phenolic ether sulfate (Triton 79)	0.1993	clear	Like control with poorer coverage. Back side of electrode is better than front
4.	Organic polyether alcohol (Triton NE)	0.2000	clear	Same as control, with slight tendency towards striation.

DISCUSSION

None of this group gave a deposit finer than the control.

Triton W-30, and Triton-79, both ether sulfates, and Triton-720, an ether sulfonate, gave somewhat of the same type of deposit as encountered in the

sulfates and sulfonates. The deposits (1) and (2) rubbed off of the electrode to a very fine powder. The deposit of Triton-79 was peculiar in that the back side of the electrode was covered to a greater extent than the front of the electrode.

Triton NE gave no precipitate with 0.25 M $AgNO_3$ solution.

UNCLASSIFIED WETTING AGENTS

Ref. No.	*Wetting Agent*	*Wt. of Deposit (grs)*	*Solution*	*Notes on Deposits*
1.	Nelgin	0.2000	clear	Smooth grey deposit, spotted with pits exposing the bare platinum, some treeing.
2.	Proflex	0 2009	clear	Finer than control, more adherent than control, striae, color of control.
3.	Blendene	0.2003	clear	Not as fine as (2).
4.	Hydromalin	0.2003	clear	Same as (3).
5.	Emulsone B	0.2000	clear	Extremely smooth grey deposit, brittle, cracks on drying

DISCUSSION

Unfortunately the compositions of these wetting agents was not known. They are all manufactured by the Glyco Products Co., Inc., and seem to belong to one type.

All of this group gave fairly well adhering deposits. Proflex and Blendene were striated, but finer and more adherent than the control. Emulsone B was a smooth deposit, but was brittle.

Further experimentation with Proflex and Blendene along the line of stirring the solutions, and revolving the cathodes, gave essentially the same type of result as was obtained for ammonium laurate. This has been discussed already.

The masses of the deposits did not vary greatly from the mass of the control.

From surface tension data available, it is known that 1% solutions of Nelgin, Proflex, and Emulsone B have a higher value for surface tension than 1% solutions of Blendene and Hydromalin. In this particular case, the wetting agents with the higher surface tension values gave the better deposits.

CONTROLS

Ref. No.	*Con. of Wetting Agent (%)*	*Current Density (Amps./dm²)*	*Temperature (°C)*	*Notes on Deposits*
1.	0.0	.25	30.7	Coarser crystals than (2).
2.	0.0	.50	30.7	Regular.
3.	0.0	1.0	30.7	Same as (2).
4.	0.0	1.5	30.7	Somewhat finer than (2).
5.	0.0	2.0	30.7	Same as (4), plus some treeing.
6.	0.0	0.25	44.6	Larger crystals than (7), poorer coverage, striae.
7.	0.0	0.50	44.6	Same size crystals as (2), better coverage, very close striae.
8.	0.0	1.0	44.6	Crystals like (2), no striae, treeting.
9.	0.0	0.25	0.0	Finer and more adherent than (2), good coverage.
10	0.0	0.50	0.0	Finer than (2), but slightly coarser than (9), good coverage.

TRIS (HYDROXYMETHYL) AMINO METHANE

Ref. No.	*Con. of Wetting Agent (%)*	*Current Density (Amps./dm²)*	*Temperature (°C)*	*Notes on Deposits*
1.	0.0001	0.5	30.2	Control.
2.	0.001	0.5	30.2	Control.
3.	0.01	0.5	30.2	Somewhat finer than control, dull white, slight striae, some treeing at the corners.
4.	0.1	0.5	30.2	Much finer than control, dull white, very very slight striae and treeing, cracks on bending.

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps/dm²)	Temperature (°C)	Notes on Deposits
5.	1.0	0.5	30.2	Finer than (4), dull white, good coverage, no striae, no treeing, buffs well, but cracks on bending.
6.	10.	0.5	30.2	Finer than (5), dull tan, excellent throwing power, adheres well, does not crack on bending, buffs well.
7.	0.0001	1.0	30.2	Control.
8.	0 001	1.0	30.2	Just slightly finer than control, very slight treeing.
9.	0.01	1.0	30 2	Finer than (8), dull white, treeing, fair coverage.
10.	0.1	1.0	30 2	Finer than (9), dull white, treeing, good coverage.
11.	1.0	1.0	30.2	Very smooth, dull white, good coverage and throwing power, buffs well, but cracks on bending.
12.	10.	1.0	30 2	Shiny silvery deposit, slight discoloration, good throwing power, buffs well, and does not crack on bending.
13.	0.0001	1.5	30.2	Control.
14.	0.001	1.5	30.2	Control.
15.	0.01	1.5	30.2	Finer than control, dull white, good coverage, slight treeing, cracks on bending.
16.	0.1	1.5	30 2	Finer than (15), dull white, excellent coverage, slight treeing, cracks on bending.
17.	1.0	1.5	30.2	Finer than (16), dull white, peculiar sheen-like vertical lines, good throwing power, does not crack on bending.
18.	10.	1.5	30.2	Discolored areas from dark brown to light tan to shiny silver, buffs well, and does not crack on bending.
19.	0.0001	2.0	30.2	Same as control, only much more treeing.
20.	0.001	2.0	30.2	Same as (19).
21.	0.01	2 0	30.2	Somewhat finer than control, less treeing than (19) and (20).
22.	0.1	2.0	30 2	Finer than (21), less treeing, dull white, poor adherence, rubs off easily.
23.	1.0	2.0	30.2	Very fine, dull white, good throwing power, sheen-like striae as in (17), cracks on bending
24.	10.	2.0	30.2	Color as in (18), less adherent than (18), does not crack on bending.
25.	1 0	.25	44.6	Black-grey flat non-crystalline, striae, some treeing.
26.	10.	.25	44 6	Slight discoloration, dull white and dull tan areas.
27.	1.0	.50	44 6	Grey well built up striae, treeing around the edges, fuzzy, less adherent than (25).
28.	10.	.50	44.6	Smooth dull white, well-adhering, good throwing power, does not crack on bending.
29.	1 0	1 0	44 6	Grey-black fuzzy striae, much more treeing than (25) and (27), less adherent.
30.	10	1.0	44 6	Smooth, dull white, well adhering, does not crack on bending.
31.	1 0	.25	0 0	Well adhering, striae of very fine, crystalline blobs and close together, no treeing
32.	10.	.25	0.0	Discoloration from smooth shiny to dull blue, fairly well adhering.
33.	1 0	.50	0.0	Same as (31).
34.	10.	0.50	0 0	Complete discoloration to dull dark brown, rubs off, poor adherence.

DISCUSSION

Tris (hydroxymethyl) amino methane, $(CH_2OH)_3CNH_2$ gave the best deposit of all of the wetting agents tried. The type of deposit produced by this wetting agent was very much like the deposit obtained with the commercial cyanide baths, *i.e.*, smooth, dull or flat white, no striae, no treeing and good adherency.

Concentrations of the wetting agent as small as 0.0001% and 0.001% had no effect at all, since the deposits were identical with those of the control. Concentrations of 0.01% produced deposits somewhat finer than the control. Concentrations of 0.1% and 1.0% produced smooth, dull white deposits, much finer

than the control. The crystals were actually so small as to give the deposit an appearance of a smooth silver paint job. Concentrations of 10%, produced smooth shiny deposits, most of which had some discoloration. The shiny areas had the appearance of unplated platinum surface. The discolorations disappeared readily on slight buffing.

Deposits (5) and (11) were excellent smooth fine-grained dull white deposits but cracked somewhat on bending. Deposits (7) and (23) were both very smooth and well covered on both sides, and had vertical lines so fine and close together as to give the appearance of silk cloth.

Increase in concentration caused a decrease in crystal size and an increase in smoothness, with variations all the way from control type to dull white type, and finally to the shiny type. Increase of current density increased treeing and throwing power, and decreased adherency.

Since concentrations of 1.0% and 10% produced the best deposits, further experimentation with such solutions at one higher temperature (45° C), and at one lower temperature (0° C) at various current densities, was tried.

An increase in temperature from 30° C to 45° C for the 10% solutions made very little difference; for the 1.0% solutions, caused some discoloration and also a tendency towards striation. A decrease in temperature from 30° C to 0° C for the 10% solutions caused the type of deposit to shift from the dull white type to the shiny type, and further to complete discoloration and decreased adherency; for the 1.0% solutions increased striation tendency, and decreased treeing.

Increase in current density at 45° C increased fuzziness and treeing, and decreased adherency; at 0° C, decreased adherency and caused increased discoloration.

EMULPHOR ELA

Ref. No.	*Con. of Wetting Agent (%)*	*Current Density (Amps./dm²)*	*Temperature (°C)*	*Notes on Deposits*
1.	0 001	0.50	30.2	Control.
2.	0 01	0 50	30.2	Control.
3.	0.1	0.50	30.2	Like control, slight striae.
4.	1.0	0 50	30.2	Well-defined striae, edges built up, fair adherence.
5.	10.	0.50	30.2	Large flaky flat shiny crystals standing off from electrode, poor adherence, striae, tan color.
6.	0 001	1.0	30.2	Control.
7	0 01	1.0	30.2	Control.
8.	0.1	1.0	30.2	Finer than control, striae very fine and close together.
9.	1.0	1.0	30.2	Same as (4), only finer, and striae closer together.
10.	10.	1.0	30.2	Flaky shiny crystals much smaller than (5), more fuzzy, and poorer adherence, tan color.
11.	0.001	1.5	30..	Finer than control, slight treeing.
12.	0.01	1.5	30.	Same as (11).
13.	0.1	1.5	30.2	Finer than (11) and (12).
14.	1 0	1.5	30.	Finer and striae closer together than (9).
15.	10.	1.5	30.	Fuzzier than (10), poor adherence, striae.
16.	0 001	2.0	30.2	Extensive treeing, otherwise like control.
17.	0.01	2 0	30.2	Finer than control, less treeing than (16).
18.	0.1	2.0	30.2	Smooth dull white, good coverage, slight treeing.
19.	1.0	2.0	30.2	Like (16) and (17), very fine striae.
20.	10.	2.0	30.2	Less fuzzy than (15), more adherent, color of control.
21.	1.0	0.25	44.6	Fuzzy, poorly defined striae, poor adherence, much treeing.
22.	1.0	0.50	44.6	Fuzzy, larger crystals, very poor adherence, almost no striae.
23.	1.0	1.0	44.6	Fuzzier and more loosely held than (21).

Ref. No	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
24.	1.0	0 25	0.0	Well adhering, well-defined striae, almost no treeing, color of control.
25.	1.0	0 50	0.0	Same as (24), except striae closer together.

DISCUSSION

Emulphor ELA is a viscous, oily, greenish-brown liquid, of composition, $RCOOCH_2CH_2OH$. In solutions of 0.25 M $AgNO_3$, in concentrations as high as 10% by volume, this wetting agent showed no precipitate formation. On long standing, the color of the solutions darkened slightly.

The type of deposit produced by this wetting agent at conditions of 1% wetting agent, 0.25 M $AgNO_3$, C.D. of 0.5 amps/dm², and 30° C, was representative of a large number of the wetting agents tried, *i.e.*, striated, fuzzy, tan colored deposits.

An increase of current density produced a smoother type deposit. Concentrations of 0.001%, 0.01% and 0.1% showed no difference from the control, at a current density of 0.5 amps/dm². At a current density of 1.0 amps/dm², there was still no change at the above concentrations. At a current density of 1.5 amps/dm², the 0.001% solution gave a deposit somewhat finer than the control. At a current density of 2.0 amps/dm² the 0.001% solution gave a deposit much finer than the control.

All of the smoother deposits of this wetting agent showed good adherency and did not crack on bending. Deposit (17) was the best deposit of the whole group.

Variations in temperature from 45° to 30° to 0° C caused an increase of adherency.

Increase of current density at 45° C caused an increase in treeing and fuzziness; at 0° C caused only a small decrease in striation.

ORGANIC POLYETHER ALCOHOL

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.0001	0.25	30.7	Large flat shiny crystals, no striae.
2.	0.001	0.25	30.7	Same as (1).
3.	0.01	0 25	30 7	Same as (1), slight striae.
4.	0.1	0.25	30 7	Same as (1), more striated.
5.	1 0	0.25	30.7	Same as (1), more striated, decreased adherence.
6.	10.	0.25	30.7	Same as (1), well striated, poor adherence.
7.	0.0001	0.50	30.7	Control.
8.	0.001	0.50	30.7	Control.
9.	0.01	0.50	30.7	Control.
10.	0.1	0 50	30 7	Like control, slight striae.
11	1.0	0 50	30.7	Fairly smooth, no treeing, no striae.
12.	10.	0.50	30.7	Large flaky flat crystals, poor adherence, larger crystals than (6).
13.	0.0001	1.0	30.7	Control.
14.	0.001	1.0	30.7	Control.
15.	0.01	1.0	30 7	Control.
16.	0.1	1.0	30.7	Control.
17.	1 0	1.0	30.7	Like control, slight striae.
18.	10.	1.0	30.7	Less flaky, more striated than (12).
19.	0.0001	2.0	30.7	Control, treeing.
20.	0.001	2.0	30.7	Control, treeing.
21.	0.01	2.0	30.7	Control, treeing.
22.	0.10	2.0	30.7	Control, treeing.
23.	1.0	2.0	30.7	Control, treeing.
24.	10.	2.0	30.7	Flat shiny crystals around the edges, striae, treeing.
25.	1.0	0.25	44.6	Larger crystals and more striated than control.
26.	1.0	0.50	44.6	Fuzzy, treeing, large flat crystals, poor adherence.

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
27	1.0	1.0	44 6	More fuzzy and less adherent than (26), edges well built up.
28.	1.0	0.25	0.0	Like control, very slight striae.
29.	1.0	0 50	0.0	Like control, very slight striae.

DISCUSSION

Triton NE (organic polyether alcohol), a molasses brown oily liquid, is a typical example of the non-ionizing type. It gave no precipitate with 0.25 M $AgNO_3$, even in concentrations as high as 10% by volume of wetting agent. On long standing, the solutions deepened in color somewhat. The uses of Triton NE given in the literature for this wetting agent, include electroplating.

Variations of current density from 0.25 to 2.0 amps/dm², caused a change in type of deposit from large flat loosely adherent crystals, to the control type, but with striae. Even in 10% solutions, at a current density of 2.0 amps/dm², the large flakes had almost disappeared, and remained only at the edges.

Decrease in temperature, 45° to 30° to 0° C, had the same type of an effect as produced by increasing the current density.

Of all of the deposits of this batch, at the various conditions, none were better than that of the control.

AEROSOL 1B

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0 0001	0 25	30.7	Control.
2.	0.001	0.25	30.7	Control.
3	0.01	0.25	30 7	Like control, striae.
4.	0 1	0.25	30 7	Striae, some treeing, edges built up.
5	1.0	0.25	30 7	Dark, dull, almost black, striae, discoloration.
6.	10.	0.25	30.7	Finer than control, discoloration, buffs fairly well.
7.	0 0001	0.50	30.7	Control.
8	0 001	0.50	30.7	Control.
9.	0.01	0.50	30 7	Control.
10	0.1	0.50	30 7	Striae, fair adherence, fine striae, delicate trees.
11.	1.0	0.50	30.7	Dull grey, brittle, striae, discoloration, treeing upwards.
12.	10.	0.50	30.7	Fine bluish grey, discoloration.
13.	0.0001	1.0	30.7	Control.
14.	0 001	1.0	30.7	Control.
15.	0 01	1.0	30.7	Control.
16	0 1	1.0	30 7	Like control, slight striae.
17.	1.0	1.0	30.7	Dull grey, striae, treeing, poorer coverage but not as brittle as (11).
18.	10.	1.0	30 7	Smooth greyish-blue, rubs off easily.
19.	0 0001	2.0	30 7	Control, treeing.
20.	0.001	2.0	30.7	Finer than control, treeing.
21	0.01	2.0	30.7	Finer than control, less treeing, fair coverage.
22	0 1	2.0	30.7	Same as (21)
23	1 0	2.0	30.7	Dull white, striae, treeing, poor coverage.
24.	10	2.0	30.7	Dull black, discoloration, treeing, rubs off easily
25.	1.0	0.25	44.6	Smooth dull white, fair coverage.
26.	10.	0.25	44.6	Smooth dull white.
27.	1.0	0.50	44.6	Smooth dull white with wide brown vertical bands, well adhering.
28.	10	0.50	44.6	Smooth dull white, discoloration to dirty tan, well adhering.
29	1 0	1.0	44.6	Same as (27) plus slight treeing.
30.	10.	1.0	44.6	More discoloration than (28), edges well built up.
31.	1.0	0.25	0 0	Bluish grey, striae, some treeting, poor throwing power.
32.	10.	0.25	0.0	Brown discoloration, some treeing.
33.	1.0	0.50	0.0	Same as (31).
34.	10.	0.50	0.0	Smooth dull blue, well adhering.

DISCUSSION

Aerosol 1B (dibutyl sodium sulfosuccinate), unlike many of the other aerosols, is extremely soluble in water. It is one of the aerosols (page 144), which did not give a precipitate with 0.25 M. $AgNO_3$. It also gave the best deposit of that group.

Variations of current density from 0.25 to 2.0 amps/dm², caused an increase in discoloration, decreased adherency, and increased treeing.

Decrease of temperature for 10% solutions, caused an increase in discoloration from dull white, to the dirty dull blue type; for 1% solutions, caused a change from a non-crystalline to a crystalline type of deposit.

Here again, as noticed before, an increase of current density has the same effect as lowering the temperature.

ALKANOL S

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.01	0.25	30.7	Control.
2.	0.1	0 25	30 7	Fuzzy white, striae, poor adherence.
3.	1.0	0.25	30.7	Extensive upward treeing in striae form.
4.	10.	0.25	30.7	Shiny smooth bluish grey, rubs off like black soot.
5.	0.01	0.50	30.7	Control.
6.	0.1	0.50	30.7	Same as (5) plus slight treeing.
7.	1.0	0.50	30.7	Extensive globular spongy treeing, poor adherence.
8.	10.	0.50	30 7	Dirty dull blue, rubs off like black soot.
9.	0.01	1.0	30 7	Control.
10.	0 1	1.0	30.7	Control.
11.	1.0	1.0	30.7	Same as (7).
12.	10.	1.0	30.7	Same as (8).
13.	0.01	2.0	30.7	Somewhat finer than control, dull white, treeing.
14.	0.1	2.0	30 7	Same as (13).
15.	1.0	2.0	30.7	Spongy, poor adherence, treeing clear across to the anode.
16.	10	2.0	30.7	Same as (8), plus treeing.

DISCUSSION

Alkanol S (sodium tetrahydro naphthalene sulfonate) gave the best deposit out of a group of twenty-two tried. It gave only very slight precipitate formation with 0.25 M $AgNO_3$.

Increase of current density from 0.25 to 2.00 amps/dm² gave for 10% solutions, dark highly discolored deposits which rubbed off easily to a dark sooty powder; for 1.0% solutions caused spongy deposits; for 0.1% solutions increased adherency and actually gave a fairly smooth dull white deposit at a current density of 2.0 amps/dm².

PYRIDINE

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.1	0 25	30.7	Grey, fuzzy, well-defined striae, treeing.
2.	1.0	0.25	30.7	Like (1) with less distinct striae, and less treeing.
3.	10.	0.25	30.7	Much finer than control, dull white, adheres well, does not crack on bending.
4.	0.1	0.50	30.7	Grey fuzzy like (1), no striae.
5.	1.0	0.50	30 7	Grey fuzzy like (2), no striae.
6.	10.	0.50	30.7	Finer than 3, but some discoloration, good throwing power, less adherent than (3).
7.	0.1	1.0	30.7	Less fuzzy and less adherent than (4).
8.	1.0	1.0	30.7	Less fuzzy and less adherent than (5).
9.	10.	1.0	30.7	Smooth dull grey, discoloration, good coverage.
10.	0.1	2.0	30.7	Smooth dull tan, some treeing.
11.	1.0	2.0	30.7	Dull tan, edges built up.
12.	10.	2.0	30.7	Smooth dull tan, some discoloration, brittle.

DISCUSSION

This tertiary amine was listed as a detergent in the literature. It undoubtedly forms a complex silver ion with silver nitrate solution, but unlike the other nine amines which were tried, did not give a precipitate on adding it to 0.25 M $AgNO_3$.

10% solutions of pyridine gave a dull white deposit much finer than the control. An increase in current density gave a smoother deposit, but caused discoloration.

An increase in current density for 1.0% and 0.1% solutions caused a decrease in fuzziness.

THE AMINES

Ref. No.	*Amine*	*Current Density (Amps./dm²)*	*Temperature (°g)*	*Notes on Deposits*
1.	Ammonium Hydroxide (Minimum con.)	0.50	30.7	Slightly finer than control, slight striae, discoloration, poor adherence.
2.	EthyleneDiamine (10%)	0.50	30.7	Dull white, sheen-like striae, good coverage and throwing power
3	Ethanol-amine (10%)	0.50	30 7	Somewhat like (2)—poorer coverage.
4.	Diethanol-amine (10%)	0.50	30 7	Very fine, sheen-like excellent coverage and throwing power.
5.	Same (10%)	0.25	44 6	Same as (4)
6.	Same (10%)	0.50	44 6	Same as (4)
7	Same (10%)	1.0	44.6	Slightly larger crystals than (4).
8.	Eame (10%)	0 25	0.0	Variations of dull and shiny areas.
9.	Same (10%)	0.50	0.0	Very fine, dull white, excellent coverage and throwing power.
10.	Triethanol-amine (Minimum con.)	0.50	30.7	Very smooth, shiny, good coverage and throwing power.
11.	n-Butyl Amine (10%)	0 50	30.7	Smooth, some discoloration.
12.	n-Amyl Amine (10%)	0.50	30.7	Very smooth, some discoloration.
13.	2-Amine-2Me-1 Propanol (10%)	0.50	30.7	Smooth dull white, not quite as good throwing power.
14.	Hydroxyethyl ethylene diamine (10%)	0.50	30.7	Extremely smooth, dull white, excellent coverage and throwing power.
15.	Same (10%)	0.25	44.6	Not quite as fine as (14).
16.	Same (10%)	0.50	44 6	Same as (14).
17.	Same (10%)	1.0	44.6	Finer than (14).
18.	Same (10%)	0.25	0.0	Extremely smooth, shiny silvery, excellent coverage and throwing power.
19.	Same (10%)	0.50	0.0	Same as (18).

DISCUSSION

This group of nine amines was run at various conditions of current density and temperature to see what effect the different types would have upon the form of the deposit. All of these amines undoubtedly form complex silver ions with silver nitrate solution. It is well known that the formation of the complex ion of the metal which is to be plated out on the cathode, causes the deposit to be more smooth. This is known to be due to decreased concentration of Ag^+ ion and also to the relatively high specific conductance which some of these complex ions possess. This increased specific conductance tends toward higher current density, which increases throwing power and decreases crystal size.

The solutions of the amines were made up to 10% by volume of the amine, *i.e.,* 25 cc of amine to 225 cc of 0.25 M $AgNO_3$. At first precipitates are formed, but further addition of amine, causes the precipitates first formed to dissolve. In the case of ammonium hydroxide, and triethanolamine, more

than 10% by volume of the amine had to be added in order to dissolve the precipitates.

Most of the deposits were of the smooth dull white type, such as are obtained with the commercial cyanide bath. The throwing power of these deposits was also comparable to commercial cyanide deposits. Only ammonium hydroxide gave a deposit poorer than that of the control.

Increase in current density caused an increase in smoothness, ranging from crystalline, to dull white, to shiny type of deposit.

Decrease in temperature had the same effect.

Thus, the variations in the types of deposits produced by changing current density and temperature, were very similar to depositions from solutions of 0.25 M $AgNO_3$, in the presence of wetting aents.

COMMERCIAL CYANIDE

Ref. No.	*Con. of Wetting Agent (%)*	*Current Density (Amps./dm²)*	*Temperature (°C)*	*Notes on Deposits*
1	0 0	0.25	30 7	Extremely fine, dull white, excellent coverage, does not crack on bending.
2.	0.0	0.50	30.7	Same as (1).
3.	0.0	1 0	30.7	Same as (1), but peels off on bending
4.	0.0	2.0	30.7	Not as good as at lower C.D.'s, more brittle.
5.	0.0	0.25	44 6	Same as (1).
6.	0.0	0.50	44.6	Same as (1).
7.	0.0	1 0	44 6	Not as shiny as (1), duller white.
8.	0.0	0.25	0.0	More shiny than (1).
9.	0.0	0.50	0.0	Same as (8).

DISCUSSION

A commercial cyanide bath was prepared as described in Blum and Hogaboom (16) p. 349. Such a solution contained enough silver chloride to give a silver content of about 25 grams Ag/liter, and 2 moles of potassium cyanide for each mole of silver chloride used.

The deposits obtained were used as a means of comparison with the other deposits.

SUMMARY

The electrodeposition of silver from silver nitrate solutions in the presence of 84 wetting agents has been studied and the results of determination of masses and characteristics of deposits recorded. The important points for each group have been already discussed. Those wetting agents which gave deposits finer than the control were, Aerosol 1B, Diglycol Stearate, Ammonium Laurate, Ammonium Stearate, Proflex, Pyridine and Tris (hydroxy methyl) amino methane. Of these eight, Tris (hydroxymethyl) amino methane gave the best deposit.

Very many types of deposits were encountered; among which were striated, treed, non-adherent, spongy, fuzzy, powdery, discolored, brittle, dull white and shiny deposits. In general, it was noticed that wetting agents almost always produced some effect; in marked contrast to the data of Taft and Horsley (5), who showed that only 60% of the 169 addition agents employed by them, produced effects. Taft and Fincke (19) in the electrodeposition of lead from lead nitrate solutions, showed also that only 35% of the 197 addition agents employed, produced effects.

Discolorations and low and high masses of deposits, indicated that other reactions than just formation and discharge of simple silver ion were taking place in some of the baths. Stareck and Taft (18) have shown that the

anodic and cathodic products in electrolytic depositions of silver may be other than just pure silver. It is not at all improbable that at higher current densities some of the wetting agents were decomposed. Hartshorn (14), claims that this is a common weakness of many wetting agents, (probably caused by oxidation at the anode.) The presence of decomposition products would certainly not lead to smooth deposits. Also, in solutions of higher concentrations of the wetting agent it was noticed that reduction to metallic silver took place quite often. There was probably present in such solutions, at least a trace of colloidal silver.

In general, the sulfates and sulfonates gave very similar deposits—extremely poor. The most common characteristic of all of the deposits was that of striations.

In general, increase of current density and decrease of temperature caused a decrease in crystal size. The formation of large crystals was quite often accompanied by treeing.

The transition from crystalline type of deposit to dull white type to shiny type to discolored type, took place quite often on variation of electrolytic conditions.

In general, 0.01% of wetting agent was the limit for producing any effect upon the form of the deposit.

From this study, there seems to be no obvious relationship between the molecular structure of the wetting agent and the form of the deposit. Finally, other factors than the production of a low surface tension of the plating bath are required to produce a good deposit.

LITERATURE CITED

1 ROSA, VINAL and McDANIFI. Bull. Bur. Standards, *9,* 211, (1912).
2. MATHERS and KUEBLER Trans Electrochem. Soc., *29,* 417, (1916).
3. S. WERNICK. Trans. Faraday Soc., *24,* 361, (1928).
4. GLAZUNOV, TEINDL, and HALIK. Chem. Listy, *29,* 117, 131, (1935).
5. TAFT and HORSLEY. Trans. Electrochem. Soc., *74,* 305, (1938).
6. TAFT. Trans. Electrochem Soc., *63,* 75, (1933).
7. The Electrochem. Soc., Modern Electroplating, (special volume) (1942).
8. JOHN E. HODGE. Master's Thesis, Uni. of Kansas, 1940.
9. OTTO E. LUTENESS. Master's Thesis, Uni. of Kansas, 1941.
10. H. L. CUPPLES. U.S. Bureau of Insecticides, June, (1940).
11. VAN ANTWERPEN. Ind. Eng Chem., *33,* pp. 16 and 740, (1941); *35,* pp. 126, (1943).
12. N. K. ADAM. The Physics and Chemistry of Surfaces, 3rd Edition, London. (1941)
13. BARTELL. Ind. Eng. Chem, *33,* *737,* (1941).
14. D. S. HARTSHORN Metal Finishing, *35,* 476, (1940).
15. DAVIS. Ind. Eng. Chem., *33,* 1546, (1941).
16. BLUM and HOGABOOM, Principles of Electroplating and Electroforming, 2nd Edition, New York (1930).
17. CARYL Ind. Eng. Chem., *33,* 731, (1941).
18. STARECK and TAFT. Trans Electrochem Soc, *67,* 97, (1935).
19. TAFT and FINCKE. Trans. Kan. Acad. Sci., *45,* 173 (1942).

20

Magnesium, Its Manufacture and Alloys

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Magnesium, although eighth in abundance among the elements, does not exist in the free state. It is found in abundance across the earth's surface in the form of magnesite, which is mainly magnesium carbonate and calcium carbonate; as brucite, the hydroxide of magnesium; as magnesium chloride in brines; as carnalite, a double salt of magnesium and potassium chlorides; as serpentine, magnesium silicate; and, in sea-water as a small percentage of magnesium chloride. It was first isolated by the Englishman, Sir Humphrey Davy, in 1860. As recently as the 1920's however, work with the metal had scarcely passed the laboratory stage.

Due to the character of magnesium oxide and the salts of magnesium, various methods of reducing the metal have been developed. Each of the methods obviously has its distinct advantages and disadvantages; they may be classified as follows: electrolytic, carbo-thermic, and silo-thermic.

The electrolytic process, developed in this country by the Dow Chemical Company, was initially developed by I. G. Farbenindustrie in Germany and improved by Magnesium Elektron, Ltd., in England. The Dow process, as it is referred to in this country, grew out of the development of a cheap raw material in the magnesium chloride liquor residue from the brine treatments designed to use this material at Midland, Michigan. Its reduction to an almost anhydrous condition using dry hydrogen chloride gas was discovered and a cell was then developed capable of electrolyzing the salt. At the Dow Freeport plant in Texas, magnesia is recovered from salt water using lime to precipitate the magnesia. This substance is then converted to hydrous magnesium chloride by the addition of hydrochloric acid; changed to the almost anhydrous condition and the resulting salt used as the electrolyte in the cell where further reduction to the metal takes place through electrolysis.

The Basic Magnesium Company at Las Vegas, Nevada, uses the electrolytic process. The magnesite ore is calcined to a degree which leaves a highly reactive magnesium oxide. This oxide is pelletted with carbonaceous material selected to give a high degree of porosity, and fed into chlorinating furnaces in which the magnesium oxide is converted to absolutely anhydrous $Mg\ Cl_2$, the electrolyte for the cells. The electric current melts and decomposes the salt in the presence of the carbonaceous material, liberating chlorine gas at the anode The residue from the impurity in the ore is filtered and recirculated until the metal floats to the surface at the cathode where it is dipped out.

The carbo-thermic process used by Permanente Metals Corporation at Permanente, California (also called the Hansgirg process) is one of the most widely discussed processes at the present time. The process which uses carbon as a reducing agent will probably be a cheap method of extraction when completely developed since it employs the simple reaction . $MgO+C+\Delta=Mg+CO$. This reaction is reversible and requires very special equipment to achieve the temperature of 2200° necessary to permit reduction toward the right. Very

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much lower temperatures are required for the backward reaction, necessitating rapid cooling of the magnesium vapor. This cooling is effected by the use of large volumes of cold natural gas or hydrogen to chill the gases formed by the above reaction as they emerge from the furnace to approximately 200° C. The magnesium vapor should immediately condense out as a very fine dust containing magnesium, carbon, and magnesium oxide. If the reaction does not work perfectly or the impingement of the gas be insufficient, the dust will be re-converted to oxide and the yields are very low. The dust itself is most dangerous because magnesium, being extremely pyrophoric, it is almost explosive in character. Consequently, it needs special treatment to avoid accidents. The metal from this stage is retorted, and the result is very pure crystalline magnesium (99.98%).

The silo-thermic process starts with dolomite and uses ferro-silicon as a reducing agent. Much work was done on this process before the war, particularly in Germany and in England. In the former country, a type of furnace was evolved which permitted a practically continuous production to two tons per day.

In Canada and in the United States, the process suddenly became prominent as a result of the war. Dolomite of good quality is calcined, mixed with ferro-silicon and heated in tubes of stainless steel about 8 to 10 inches in diameter, to 2140°F at a pressure of 50 to 100 microns. The heat is applied externally. The magnesium in the dolomite distills and is collected at the end of the tube which is water cooled.

The ferro-silicon process has proved quite valuable at this particular time due to the speed with which the dolomite is processed into metallic magnesium, and also to the simplified and relatively standardized equipment used in the reduction. However, the over-all cost is high because of the quality of the retorts which have a short life expectancy, and also because of the high cost of ferro-silicon.

The melting of magnesium is usually done in an oil or gas fired furnace, the melting pot which is made from cast iron is semi-spherical in shape. After reaching a temperature of 650°C, the metal begins to melt very rapidly.

Magnesium forms alloys with most of the common metals, yielding products with a wide range of properties The composition of most of these alloys may be divided into two general groups: first, those having only one additional added metal, usually aluminum (10 to 12%); second, a group with two or more added metals; these additions usually include aluminum and zinc in varying proportions with other metals such as manganese, and sometimes lead, beryllium, cerium or silver.

Some properties of magnesium are:*

Coefficient of expansion @ 20°C=24.34×10^{-6}
Modulus of elasticity=6.5×10^{6} lbs./in^{2}
Modulus of torsion=2.6×10^{6} lbs./in^{2}
Electrical conductivity=37.8% of copper standard
Thermal conductivity=44.4% of copper standard

Aluminum is used as a hardener to improve the properties of magnesium in the "as cast" condition, and to assist grain refinement. The castability of

*Walker, Harold L., A Correlated Abstract of the Physical Metallurgy of Magnesium and Its Alloys, Bulletin T, Mining Experiment Station and State Metallurgical Research Laboratories. State College of Washington, 1938.

magnesium-aluminum alloys rises with increasing aluminum content up to about 10% aluminum. In addition to being castable and giving good mechanical properties, these alloys are also suitable for extrusion and forging; those with 6 to 9% aluminum content giving high proof-stress figures of the order of 15 tons/in^2 when forged and heat-treated.

Zinc further improves the castability of magnesium-aluminum alloys if limited to not more than 3%. Additions of more than 3% will lead to hot shortness and cracking, as well as to lack of pressure tightness. High zinc content is liable to create inter-granular voids, more commonly known as micro-shrinkage. Therefore, the zinc addition should be kept below 3%.

Manganese is one of the most useful alloying elements. The solid solution of magnesium and manganese has excellent corrosion resisting properties, provided it is free from iron. Such corrosion resistance is probably due to the presence of an invisible film of manganous hydroxide on the surface which has a strong protective action and is reasonably robust.

Special processes have been developed permitting the introduction of pure manganese. As a result, a magnesium alloy containing only about 1.5 to 2% manganese is the most corrosion resistant of magnesium rich alloys yet known; it also has fairly good mechanical properties. With magnesium aluminum alloys, manganese has an equally beneficial effect in inhibiting corrosion, but in these cases, the effective addition of manganese is limited to 0.3 to 0.5%. The presence of manganese is also stated to improve the free cutting properties of the alloy.

The primary advantage of the use of magnesium alloys for engineering purposes is their lightness combined with good mechanical properties. The best wrought magnesium alloys have mechanical properties of the same order as duraluminum, and, therefore, their low density, only 60% that of aluminum, allows much higher specific tenacity figures and hence great weight saving potentialities.

As has been stated, the modulus of elasticity is distinctly lower for magnesium alloys than for aluminum alloys. This quality has a considerable value in all cases in which a component is subjected to elastic vibrations, since for a given amplitude of deflection, the stress in the metal varies as the value of the modulus. Therefore, a given deflection in a magnesium component involves a lower stress within the material than in a corresponding part of aluminum. This low stress may be of particular importance in parts subject to large amplitudes of "critical" vibrations In such cases the low value of the modulus will help a magnesium alloy part to weather a storm where another kind of part would fail The low value of the modulus and of the density also contributes to a substantial reduction or elimination of noise in magnesium alloy parts which are subject to vibration, such as gear box covers and covers for restricting (aircraft) engines.

Magnesium alloys have valuable fatigue properties and very high damping capacity, and these have been taken advantage of by the Germans and the French in the design of artillery wheels, and by the English in aircraft landing wheels. The United States has profited by the experience of these other nations in its processes of manufacture and in its uses of magnesium. The present and future importance of the light metals promises to bring magnesium into ever greater prominence.

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A Study of the Relationship Existing Between Certain Insects and Some Native Western Kansas Forbs and Weedy Plants

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To the casual observer perhaps no sight could be more commonplace than that of an insect alighting upon a Kansas sunflower. But the relationship which exists between plant and insect is a matter which is often unknown even to the specialist. And yet a lack of understanding of these relationships has at times resulted in inconvenience, loss, and even in calamity. To determine some of the relationships which certain insects bear to some of our native western Kansas forbs and weedy plants is the purpose of this study.

Included in the investigation are those insects which spend at least a part of their lives beneath the epidermis of the plant root, stem, or leaf or within the inflorescence, fruits, or galls produced by the plants. Insects which may consume internal as well as external parts but which do not at some time inhabit the plant body or its products are excluded from consideration.

During the summer of 1941 in connection with a course in plant ecology the problem presented itself to determine the fate of the seeds produced by the white beard-tongue, *(Pentstemon albidus)*. The final tabulation of the results of the study showed that insects destroyed approximately 55% of the seeds produced within two months after flowering. An investigation was then begun to determine which insects were probably most effective in destroying the seeds. Large numbers of plants were dug and carefully examined. It was found that two insects commonly inhabit the seed capsules. These insects were studied in some detail and their life cycles observed. This proved so interesting that a study of additional native plants and weeds was determined upon in order to ascertain if possible which insects most commonly affect internal parts of these plants.

In each case a superficial study of the plants was made in the field Among large numbers of plants examined those were selected for special study and dissection which gave indications of insect infestation. These were dug and taken to the laboratory and completely dissected. Each root, stem, petiole, leaf, flower, fruit, and gall was carefully examined and all parts which might harbor insects were fully dissected. Insects found were kept and cultured for further observation. It was found extremely difficult to keep certain burrowing types alive because of the attacks of molds and other fungi when containers were kept closed.

Plants were collected from 15 different locations in western Kansas all within a radius of about 80 miles to the east, north, west, or southwest of Hays.

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PENTSTEMON ALBIDUS NUTT.

The white beard-tongue, *(Pentstemon albidus)* is listed by Albertson (1) as a forb of secondary importance in the mixed prairie. In the study preliminary to the present problem the plant was found to possess an increase potential of four thousandfold yet it never attains the status of a dominant in its native habitat.

A careful examination on July 16, 1941, of 25 plants bearing 218 seed capsules showed 109 of them to have been damaged by insects

Of the three species of insects found feeding upon the seeds in the capsules only two are considered of importance in the present study since the third was found in only one capsule. The first, *Phytomyza chrysanthemi* Kowarz, is a fly 4 mm. long (the wings making up half this length), and 1.5 mm. in width. On June 14, 1941 a waxy, legless grub 4 mm. long and 1.7 mm. in diameter, with a funnel-like proboscis at the cephalic end (Fig. 8) was found feeding upon the seeds. This larva pupated on June 20 becoming a dark brown pupa slightly less than 4 mm. in length and slightly more than 1 mm. in width (Fig. 9). In 204 capsules opened, 29 larvae or pupae of this species were found. Some of the dwarfed capsules contained pupae of this insect. One capsule of normal size contained two In most cases one insect was found to consume all of the seeds of a single capsule.

Since none of these insects emerged through the months of June and July, four pupae were placed in a refrigerator on August 2 and kept at a temperature of 36° to 40° F until August 9. Then they were removed but they did not emerge until May, 1942 On June 2, 1942 the last of the living insects emerged, those treated in the refrigerator being neither first nor last to appear.

Another insect found within the capsule was a plume moth of the *Pterophoridae*. This species was found in 31 of the 204 capsules. In 71 additional capsules perforations and fecal pellets indicated occupancy by this species. The larva of this insect (Fig. 1) is dusky red above and light green below with greenish lateral lines on each side The head is yellowish. The larva is 12 mm in length and slightly more than 1 mm. in width. When ready to pupate the larva cuts an emergence hole to the outside. This emergence hole is usually near the pedicel, though at times it may be near the apex of the capsule. Occasionally two larvae are found to occupy a single capsule and perhaps at times one larva consumes the seeds of two capsules. In 4 capsules a hole was found cut through the sepals but not into the capsule, indicating that the cutting was done from the outside. One larva taken from a capsule in which all of the seeds had been consumed was placed in another capsule in which a small opening had been made. The larva at once began to feed and continued until all of the seeds had been consumed after which it emerged and pupated normally.

After emerging the larva spins a carpet of silk about 15 mm. in length and 2 mm. in width. This silk is usually attached to the stem of the plant. The insect then attaches itself near the anal end so that it comes to lie on silk throughout its entire length. When disturbed the chrysalis slaps back violently with its anterior part, thus forming a reverse letter C, while keeping only its posterior segments in contact with the silk.

EXPLANATION OF FIGURES

Fig.
1. Larva of plume moth infesting *Pentstemon albidus.*
2. Chrysalis of same plume moth.
3. Adult plume moth.
4. Open gall of midge on *Aster multiflorus.*
5. Polythalamous gall sectioned.
6. Apical bud gall of *Solidago canadensis.*
7. Normal gall on *Aster multiflorus.*
8. Larva of *Phytomyza chrysanthemi.*
9. Pupa of same fly.
10. Stem gall on *Lygodesmia juncea.*
11. Same showing cavity.
12. Combination of galls on *Lygodesmia.*
13. Root gall of *Antistrophus pisum* on root of *Lygodesmia*
14. Typical gall of *Antistrophus pisum.*
15. Stem gall on *Sitilias grandiflora.*

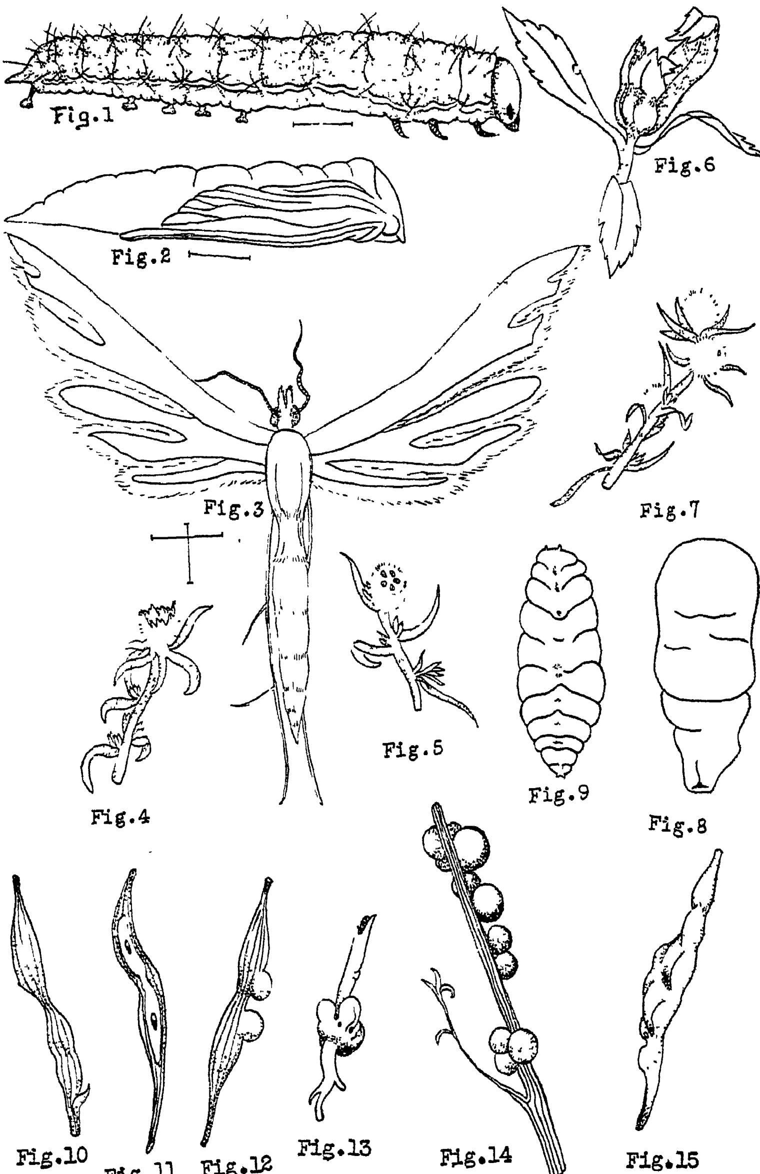
Fig.1
Fig.2
Fig.3
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Fig.5
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Fig.12
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Fig.15

The chrysalis is usually reddish brown or greenish, 11 mm. in length (Fig. 2). The first of the larvae pupated on July 7 and emerged as an adult on July 14, 1941. Other moths emerged in from 2 to 8 days after pupating, the usual time being 7 days.

The adult moth is light tan, the wings marked with darker lines. The fore-wings are bifid, cleft from about ¾, the hind wings are trifid. The wings are 15 to 17 mm in expanse (Fig. 3). Numerous adults were kept in vials but no eggs were laid nor was copulation observed at any time. This would lead to the belief that only one sex, probably the male, was represented and that the other sex would probably be found in another situation. Most of the moths lived from 8 to 9 days after emergence.

This species of *Pterophoridae* and *Phytomyza chrysanthemi* undoubtedly represent potential checks upon *Pentstemon albidus,* the plume moth being found in exactly 50% of the capsules opened and *Phytomyza chrysanthemi* in 14% of the capsules.

VERNONIA BALDWINI TORR.

In the present study 32 plants of *Vernonia baldwini* were collected and dissected. They were taken from five different localities all in Ellis County. At one place, along the Smoky Hill River south of Ellis, the plant was not to be found Two miles north of the river, however, it began to appear in the pastures. Plants taken from this area were entirely free from insects, while the plants in other locations were being attacked by a host of insects.

Among the seeds of 1135 heads that were dissected 4 different species of insects were found pupating: *Zaglyptonotus schwarzi* Cwfd., *Pachyneuron mucronatum* (Gir.) and 2 unnamed species of *Eurytoma.* The species of *Eurytoma* being commonly phytophagus, are probably responsible for the greatest destruction of the seeds. *Pachyneuron* being parasitic, according to Essig (7), is probably parasitic upon the species of *Eurytoma*

Three species of insects emerged from pupae found attached to the outside of the involucre, the seeds bearing evidence of infestation These included a third species of *Eurytoma* and two species of diptera, *Leucopis griseola* (Fallén) and *Neaspilota alba* Loew. The first named dipteron is mentioned by Essig (7) as a very efficient destroyer of aphids of the stems and leaves of plants. This fact may throw this insect outside the scope of the present paper. Curran (6) says that the larvae of the *Trypetidae* commonly live in the seeds and fruits of plants. Some live in the heads of thistles, some make galls on the goldenrods and still others are leaf miners. *Neaspilota alba* was reared from flowers and from seed by Schwitzgebel and Wilbur (13)

The most effective insects inhabiting *Vernonia baldwini* in the present study were the insects eating the seeds. In one count of 186 heads from 4 areas it was found that 59.6% of the seeds had been destroyed.

LIATRIS PUNCTATA HOOKER

According to Albertson (1) the blazing star, *Liatris punctata* is one of the characteristic forbs of the little blue stem habitat, occurring on sunny slopes and rocky outcrops of the mixed prairie. Known also as the Kansas gay feather this plant adds a flash of purple to the browning autumnal landscape. It is also a prominent forb in the short grass habitat on the flat hilltops.

Many plants of this species were examined in the field and 65 plants bearing 277 stems were collected in 9 different localities of western Kansas. These

plants were carefully dissected and only 10 insects, of 3 species, were found. Of these 8 emerged from what appeared to be egg-like pupae inserted into the stem some six or eight inches above the surface of the ground. These egg-like structures were found quite frequently in both *L. punctata,* and *Ratibida columnaris* Minute punctures produced spots on the outside of the stems betraying the presence of these structures. The spots are so small that they would probably escape notice but for the fact that a series of them is usually placed at regular intervals of from 1 to 3 mm. for a distance of 13 to 20 mm. along the stem.

Under the microscope these punctures appear as gaping wounds with the epidermal tissue bulging and torn around the puncture The entire punctured area is usually somewhat discolored. On June 25 a stem was dissected and a series of these egg-like structures found but two of them were dark in color instead of the usual orange. When two days later adults emerged they were found to be Chalcid wasps. Both thorax and abdomen are brilliant green. The legs are light yellow. This insect has been identified as *Eupelmus allynii* Fr. a parasite of the Hessian fly and therefore perhaps also parasitic upon the insect which produced the punctures. Another insect taken from stems is *Polynema bifasciatipenne* (Gir.).

From a pupa discovered among the seeds a species of *Eurytoma* was cultured.

None of these insects could be shown to be seriously affecting the plant body of *L. punctata* nor to be interfering to any appreciable extent with seed production.

SOLIDAGO CANADENSIS (L.)

The goldenrod, *Soldiago canadensis,* is one of the rarer composites of the prairie, being found commonly only along the streams in western Kansas.

One of the *Gelechiidae,* presumably *Gnorimoschema* species, was found to be commonly infesting the plant. In one count of 138 stalks on August 1, 1941, thirty-five galls of this species were found (Plate 4). The same stalks bore 42 galls from which *Zatropis nigroaeneus* Ashmead and *Aprostocetus americanus* Ashmead emerged. The former pupated on August 7 and emerged on August 9, 1941. *A. americanus* was found in the pupal state on August 12 and emerged on August 13.

A species of *Ceroptres* was taken in the pupal stage attached to the terminal bud (Fig 6). According to Essig (7) this wasp has been reared from various galls.

None of the insects noted in this investigation seem appreciably to injure the plants except one producing an apical rosette gall and an apical bud gall neither of which was successfully cultured

SIDERANTHUS SPINULOSUS (PURSH) SWEET

From 9 areas within a radius of 65 miles of Hays 376 stems of *Sideranthus spinulosus* bearing 1232 heads were collected. This plant which according to Albertson (1) is another prominent forb of the short grass habitat seems to be affected principally by a single species of insect. Practically every seed had been destroyed in 692 of the heads. The wasp responsible, *Eurytoma neomexicana* Gir. destroys the seed and then pupates in the receptacle among the pappus. The pupa is slightly less than 3 mm. long. Its color is pale yellow

to whitish. The adult wasp is black with pale brown to yellowish legs and black antennae.

This wasp had damaged 56% of the seed heads. It was found in every location except one. At this place, about 10 miles north of Quinter, the vegetation had suffered severely from dust. The two plants found in this area had 23 stems but only 7 heads were in bloom when the plants were taken on August 7. Undoubtedly this insect was an effective check upon *Sideranthus spinulosus.*

ASTER MULTIFLORUS AIT.

The many flowered aster *(Aster multiflorus)* as the name indicates, is one of our most prolific asters, being covered with hundreds of small white flowering heads from early September until the snow covers it. As a result it has a tendency to become a pest, invading lawns, fence-rows, and vacant areas where its perennial root makes it somewhat difficult to eradicate.

Among the insects which affect this plant Felt (8) lists one lepidopterous insect invading the roots and Stebbins (14) describes galls induced by two hymenopterous insects Neither of these was discovered in the present investigation but a gall similar to one described by Stebbins commonly affects the plant in this area.

This globose to ovate gall (Plate 1) is polythalamous, 4 mm to 7 mm. in length and 3 mm. to 5 mm. in width. The gall is green, densely covered with white pubescence (Fig. 5). Of these galls 127 were collected and cultured. Two types of insects emerged from this gall. In the case of the one insect the gall splits at maturity (Fig. 4) for some distance across the apex so that the occupants may emerge without biting their way out. This gall gives rise to a midge the pupa of which is 2.5 mm. in length with a thick, red, abdomen. The genital segments are attenuate. One adult emerged on August 14, 1941, and others were observed to emerge during July, 1942. The adult midge of the family *Itonididae* is 3 mm. long with a wing expanse of 6 to 7 mm. The abdomen is red, the genital segments attenuate as in the pupa.

From a gall which is indistinguishable from the foregoing (Fig. 7) with the exception that it was not split when the insect emerged, a wasp, *Pseudotorymus* sp. probably parasitic upon the midge, was found biting its way out on August 12, 1941. Another of this species emerged on August 14 and numerous others throughout the month, both males and females being common. Seven of the same species emerged from June 24 to July 2, 1942, but these were all females. From the same type of gall two specimens of *Amblymerus* emerged on June 24, 1942.

One gall was found to contain five thalami (Fig. 5) in each of which a cluster of minute pupae was discovered. These pupae produced a species of *Platygaster,* probably a parasite of the Itonidid.

During the month of June, 226 plants were carefully examined and 65 plants dissected. These yielded no insect except those contained in 27 galls. During the months of July and August the galls became more numerous, 28 galls having been found on a single small plant, (Plate 1).

Considerable differences in the degree of infestation were noted in different localities. In one place 97 plants bore some 20 galls early in July while one block away some 40 plants bore not a single gall throughout the months of July and August. The author believes that these insects are potential checks upon *Aster multiflorus* but that they are not at present seriously affecting the

EXPLANATION OF PLATES

Plate

1. Galls of midge on *Aster multiflours.*
2 Malformed head of *Ratibida columnaris.*
3. Rosette galls on *Solidago canadensis.*
4. Stems of *Solidago canadensis* showing galls.

plant. Since they commonly induce galls to grow from the terminal bud they would effectually hinder seed production by a heavy infestation as in the plant on Plate 1.

RATIBIDA COLUMNARIS (SIMS) T-G

The tall headed coneflower *(Ratibida columnaris)* is one of the most prominent forbs throughout the mixed prairie area. It seems to be more susceptible to damage by insects attacking from without than from within. In one count, made on August 7, 1941, every one of the 42 heads showed external damage but not one bore indications of internal infestation. On 43 stems 335 heads were carefully dissected. Only one insect was found to inhabit the stems and roots. This insect, a borer, was found in the larval form drilling downward in the stem in two plants and in the root of a third. The stems were kept and from them *Polynema bifasciatipennis* Gir. appeared. Since all of the species of *Polynema* listed by Essig (7) are parasitic either upon the eggs or larvae of other species the identity of the borer itself is still to be ascertained. As before mentioned in the discussion of *Liatris punctata* the same small egg-like pupae were found imbedded in the stems of *R columnaris* which produced *Eupelmus allynii* Fr.

One plant of *R columnaris* was found in which the main stem was broad and flat, being about one half inch wide and ending in a fan-shaped head 2 inches wide at the top (Plate 2). Dissection revealed no internal insects except the egg-like structures. The plant was infested with ants which made their den among the roots. Ten of the 26 heads were excessively broadened or dichotomous.

From observations made in this study it would seem that *Ratibida columnaris* is little affected by insects that inhabit it.

HELIANTHUS ANNUUS L.

The most commonly infested plant of this study has been found to be the annual sunflower *(Helianthus annuus)*, which has become a weedy nuisance throughout the area. In one count of 48 heads of this plant dissected, 45 were found to contain one or more larvae and the others gave evidence of earlier infestation. Ten stems dissected at the same time showed every one burrowed by insects.

A total of 62 plants bearing 162 heads were dissected These were collected from 4 different areas in Ellis County, at Quinter and at Lucas. From many additional plants separate parts were dissected. Eight different species of insects were reared from the heads, four from the stems, and one from the roots The insect found in the roots was not successfully cultured to the adult stage however.

Among the insects discovered causing damage to the seeds a prominent one is the Angumois grain moth, *Sitotroga cerealella* (Olivier). Essig (7) says this insect was introduced to America prior to 1743 and was the first insect to be discussed in an American scientific paper. The larva and pupa were discovered among the seeds in the head. Another lepidopteron which was found very commonly in the heads is probably *Hellula undalis* Fabr. Two probable parasites of *H. undalis* also were cultured from the heads. *Cremastus facilis* (Cress.) appeared in a number of culture vials and another species of *Ichneumonidae* of the genus *Angitia*. Some of the *Angitia* are listed by Essig (7) as parasites of *H. undalis*. Other lepidoptera obtained from the heads of *H.*

annuus are a member of the family *Tineidae,* a species of *Homeosoma,* and a species of *Phycitidae.* An *Ichneumon* found in association with them is a species of *Macrocentrus* Whether or not this specimen is parasitic upon either of the foregoing remains to be ascertained.

Among the insects inhabiting the stems the largest found was the coleopteron, *Rhodobaenus tredecimpunctatus* Ill. Tucker (14) lists this insect as commonly found on the sunflower but makes no mention of its breeding inside the plant. Schwitzgebel and Wilbur (12), who found this species on *Vernonia interior* quote Blatchley and Leng (12) as stating that the insect breeds in many compositae including the sunflower. The specimen in the present study was discovered on August 2, 1941, as a pupa located in the root of a plant. A burrow had been dug from a place about 30 inches above the surface of the ground down to the root. The pupa lay at the bottom of this burrow The adult emerged on August 5. Another inhabitant of the stem, *Agromyza virens* (Loew), was found in the pupal stage in the transition zone near the surface of the ground. On June 20, 1942 the pupa was found in a plant which was swollen at this point and a crack in the cortex seemed to indicate an open gall. The gall very closely resembles that of the grape-vine gall, made by the stimulation of *Bardius sesostris* Le Conte (11). This insect is listed by Essig (7) as one of the stem miners. In the present case the mine was somewhat deep, leading to the tentative classification as a stem borer.

At Quinter, Kansas, a lepidopteron was found very commonly infesting the leaf petioles and pupating usually in the axil, where an exudation formed a sticky mass which was easily detected. This insect is a species of *Olethreutidae,* probably *Sulcima heliantha* (Riley). It was taken in considerable numbers on August 7. This insect was not collected in any other location.

The largest dipteron taken from *H. annuus* is *Euxesta notata* (Wd) which pupated in the stem about half an inch below the basal disk The pupal case was dark red, 5 mm long and 1 5 mm. in diameter. The adult emerged on July 7, 1942.

In view of the fact that so many insects infest the various parts of *H. annuus* it is difficult to estimate the damage done by an individual species except in relation to its frequency of occurrence. The most common of all were the *Sitotroga cerealella* and the *Hellula undalis* one or both of which occurred in 63.3% of the heads

LYGODESMIA JUNCEA PURSH

The skeleton weed *(Lygodesmia juncea)* is one of the forbs of secondary importance in the short grass area as well as in the little blue stem habitat (1).

At Hays 62 plants of this species were collected on August 12, 1941, June 8, and July 6, 1942. The 10 plants selected from a group of about 60 on August 12, 1941, bore 147 pea-shaped galls (Fig 14) from which *Antistrophoplex bicolorpes* Cwfd were reared. Felt (8) lists *Aylax pisum,* a synipid, as occupant of a pea-like gall on this plant, but later revises the name (9) listing it as *Antistrophus pisum* which conforms to the original description by Walsh (11). On August 12, 1941, a root gall (Fig 13) was collected near Science Hall on the Fort Hays College campus. This gall was kept and when examined early in May, 1942, showed no signs of life but when it was examined on June 1, 1942, it was found that 12 specimens of *Antistrophus pisum* had emerged. All

of these were dead when discovered. For a comparison of the galls see Figures 13 and 14.

On August 5, 1941, another type of gall was discovered on plants growing on the banks of the Saline River north of Ellis. From 8 plants, 17 of these galls were collected. From them (Fig. 10, 11, and 12) another wasp, *Eupelmus allynii* Fr. was reared. Packard (10) made a detailed study of the life cycle of this insect and its relation to the Hessian fly, *Mayetiola destructor* (Say). He lists *E. allynii* as one of the most important parasites of the Hessian fly. Since this is a known parasite of other forms it is probable that the gall in this case was produced by another insect of which unfortunately we have not obtained a specimen.

Neither of the galls observed on this plant seemed appreciably to affect the plant. No other insects were detected in any other part of the plant.

SITILIAS GRANDIFLORA (NUTT.) GREENE

The false dandelion *(Sitilias grandiflora)* is of only local importance on the prairie, being generally rather sparsely distributed. But 7 plants were collected on June 6, 1942, as they were obtained only a day before the area was mowed. A gall was found on stems and petioles as many as 17 galls being crowded into one and one-fourth inch of the stem in one case. As a result the stems were commonly deformed but the galls did not seem to interfere with anthesis and seed production. (Fig. 15)

The pale yellow pupa is 5 mm. in length. The adult is 3 mm. in length and of a dull non-metalic black color. This insect has been identified as *Eurytoma pater.* Gir.

SUMMARY

In this study 10 native prairie plants have been examined as collected from 15 areas in western Kansas. These were found to be hosts to a large population of insects. Of these 46 were studied. The rate of infestation was found

SUMMARY TABULATION

Plant	Insect	Part of Plant infested	Abundance of Insect	Effectiveness as a Check
Penstemon albidus	*Phytomyza chrysanthemi*	Seeds	14%	Possible check
	Pterophoridae sp.	Seeds	50%	Effective check
Vernonia baldwini	3 *Eurytoma* spp.	Seeds	59 6%	Possible check
	Neaspilota alba	Seeds		
Liatris punctata	*Eurytoma* sp	Seeds		Slight effect
Solidago canadensis	*Gelechiidae*	Stem gall	25 3%	Not effective checks
	Zatropis nigroaenus	Stem gall	30 4%	
	Apostocetus americanus			
	Ceroptres sp.	Bud gall		
Sideranthus spinulosus	*Eurytoma neomexicana*	Seeds	56%	Effective check
Aster multiflorus	*Itonidae* sp.	Bud gall	6%-50%	Potential check
Helianthus annuus	*Sitotroga cerealella*	Seeds	63.3%	Potential checks
	Hellula undalis	Seeds		
	Tineidae sp	Seeds		
	Homeosoma sp.	Seeds		
	Phycitidae sp	Seeds		
	Rhodobaenus tredecimpunctatus	Stems	1 6%	
	Agromyza virens	Stem	1.6%	
	Suleima helianthana	Petioles	Local	
	Euxesta notata	Stem		
Lygodesmia juncea	*Antistrophus pisum*	Root gall	1.6%	Not effective check
Sitilias grandiflora	*Eurytoma pater*	Stems and Petiole gall		Effect slight

to vary from .45 to 68 per cent. Several insects were found effective checks of their host plants, while the majority seemed to exert little effect upon them. The distribution of the insects was found to vary from a single area to eight locations as widely separated as Phillipsburg, Quinter, Hoxie, and Ness City.

LITERATURE CITED

1. ALBERTSON, F. W. 1937. Ecology of the mixed prairie in West Central Kansas. Ecol. Monographs. 7.481-547.
2. ASHMEAD, W. H. 1904. Classification of the chalcis-flies. Mem. Carnegie Mus. 1:I-XII and 225-532.
3. BLATCHLEY, WILLIAM STANLEY. Coleoptera known to occur in Indiana. Indianapolis, Nature Publishing Company. 1910.
4. BRUES, CHARLES T. and MELANDER, A. L. Classification of insects Cambridge, Harvard Press 1932.
5. COMSTOCK, JOHN HENRY. An introduction to entomology Ithaca, The Comstock Publishing Company. 1924
6. CURRAN, CHARLES HOWARD. The families and genera of North American diptera. New York, The Ballou Press. 1934.
7. ESSIG, EDWARD OLIVER. Insects of Western North America New York, The Macmillan Company. 1926.
8. FELT, EPHRAIM PORTER. Key to North American insect galls Albany, The University of New York. 1918.
9. FELT, EPHRAIM PORTER. Plant galls and gall makers. Ithaca, The Comstock Publishing Company. 1940.
10. PACKARD, CLYDE MONROE. Life history and methods of rearing Hessian fly parasites. Jour. Agr. Res. 6:367-381. 1916.
11. RILEY, CHARLES V. and WALSH, BENJAMIN. The Lygodesmia pea gall. Am. Ent. 2:73-74. 1869.
12. SCHWITZGEBEL, R. B. and WILBUR, D. A. Coleoptera associated with ironweed, *Vernonia interior* Small in Kansas Jour. Kans. Ent. Soc. 15:37-44. 1942.
13. SCHWITZGEBEL, R. B. and WILBUR, D. A. Diptera associated with ironweed, *Vernonia interior* Small in Kansas. Jour. Kans. Ent. Soc. 16:4-13 1943.
14. STEBBINS, FANNIE A. Insect galls of Springfield, Massachusetts and vicinity. Springfield Mus. Nat. Hist. 1909.
15. VIERECK, HENRY LORENZ The hymenoptera of Connecticut. Hartford, The Case, Lockwood, and Brainard Company 1916.
16. WELLHOUSE, WALTER HOUSELEY How insects live. New York, The Macmillan Company. 1926.

22

Fossiliferous Phosphatic Nodules of the Haskell Limestone Horizon

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Fossiliferous phosphatic nodules which appear to have taken their shape from the fossil contained, occur in strata located stratigraphically at the disconformity marking the Haskell limestone horizon. The most prolific nodular bed lies directly on top of the Haskell limestone; nodules are also found embedded in the Haskell limestone itself, and one, at least, was dug from the Myalina bed in the Vinland marine shale immediately below the Haskell horizon. They also occur in the Robbins shale immediately above the Haskell limestone.

These nodules have been known to me since 1884, when I first collected them, and discovered that they contained fossils. As early as 1895, I showed specimens of these fossils to Dr. S. W. Williston at Kansas University, remarking that certain ones were "bones and skulls of mammals". He corrected me merely by saying, "amphibians". Later I left some of them with Professor Roy Moody who informed me that "there were no bones at that time," (Carboniferous Period). He changed his mind later, however, since in the *Transactions of the Kansas Academy* for 1909, he published a paper on the vertebrate remains from the Carboniferous. On January 15, 1923, after preliminary letters relative to books needed for the identification of Kansas coal plants, I mailed, at the request of Dr. David White, Chief Paleontologist, U.S. Geological Survey, a package of these nodular fossils to the Smithsonian Institution, Washington, D.C At first the government scientists recognized the fossil wood, because Dr. White was a paleo-botanist and more interested in plant life. It was in line with my inquiries. Later Elasmobranch fish remains were recognized. Later yet, after clay squeezes were made of the interior, what seemed to be the brain case of an animal* was recognizd as may be seen by the following excerpt from a letter five years later, written by Dr. White to me under the date April 12, 1928, "As was reported to you some time later, there was considerable difference of opinion among the paleontologists of the

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EXPLANATION OF FIGURES (See opposite page)

FIG 1. Longitudinal section of fossil wood from phosphatic concretions, Haskell Horizon, Palmyra Township, Douglas County, Kansas. Approximately X5

FIG 2. Cross section of above, approximately X5. The microscopic slides upon which both Figures 1 and 2 are based were furnished through the courtesy of the United States National Museum, Washington, D C.

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*There is still some doubt in my mind as to whether these "skulls" may not be segments of crustaceans similar to Echinocaris of the Devonian The argument against this conclusion is that the tripartate tail parts of such crustaceans are too rare as compared with the "skulls." The internal caste has all the appearance of vertebrates higher than fish Of about a dozen fish body portions examined, not one has the skull or head in the same nodule with the fin and scale body assembly. The "skulls" occur in a ratio of about 20 to 1 fish body parts. "Skulls" and fin spines alone are associated in the same nodule rather rarely.

Geological Survey and also in the National Museum as to the nature of some of the material; more particularly that listed by you as 'skulls'. I am very glad to say, however, that in the light of subsequent studies, opinion tends to confirm your interpretations of the fossil material sent." It was at the suggestion of Dr. White that I made further extensive collections of these fossils. Some 200 choice representative nodules of this horizon containing fossils of my collecting from outcrops in several localities and now in the Baker University Museum, form the basis for these notes.

The contents of these nodules include teeth and possibly bones of large fishes; parts of small fish, scales, fins, and tail fins, some nearly entire; coprolites; cirripeds, tail parts of higher crustaceans which have been intepreted as wings of insects; phosphatic-shelled brachiopods; orthoceratites; nautaloid and ammonoid cephalopods; possible skulls, several of which seem to have the brain case intact; and numerous other scale-like plates of unknown origin. Besides the nuclei mentioned, some of the nodules enclose finely preserved fossil wood. (Figs. 1 and 2)

That these nodules were hardened before the deposition of the shales which cover the Haskell, seems proven by lack of flattening and distortion common to most nodules occurring in other Kansas shales. Later, these nodules were used as attachment bases by horn corals with well developed citrices of attachment plainly fastened to the nodules in order to hold themselves upright. Two other fossils were found attached which are both common to the nodules and to the Haskell limestone.

Some of the concretionary nodules were started unquestionably around a coprolite as a nucleus. It would be an error, however, to assume that because some of the nuclei are plainly coprolites, that all phosphatic nodules are of like origin. Some of them show strong indications of algae growth. On the basis of having broken and examined thousands of nodules, I have reached the conclusion that the deciding factor in the phosphatization of the nodules was the presence of the phosphorus content in the animal matter of the nucleus. When phosphorus was not present, nodules of other than phosphate of lime were formed. Iron oxide nodules are also found at or very near the phosphatic nodule horizon, but their content is altogether different. Similar phosphatic fossils are also found occasionally without nodules, but there is a possibility that they may have been freed in the process of quarrying.

The wood specimen illustrated was found free from its matrix; but accompanying fragments of the nodule plainly showed that it had been enclosed but later released when workmen quarried the Haskell stratum.

23
The Geological History of the Coal Lands of Southeastern Kansas

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The early geological history of the region now occupied by the coal fields is indeed interesting. These fields, as we know them today, were formed only a very short time ago, geologically speaking.

Today we wish to inquire into the past of this region and to review briefly what took place before the coal lands were brought forth as we find them now. Geologic time previous to the actual formation of the coal of the coal fields was perhaps about four times as great as the time elapsed since their making. The story of all these past ages may be found in the material of which they are built. This is a long story but very interesting, even though some of the pages in their history are missing and some records are almost illegible. Many of the chapters in this story are difficult to read, while others are plain and easy to understand. The language is consistent, and the key to the history is limited only by our knowledge of all of the geological processes as they are going on today.

If we should paraphrase the book of Genesis, we would say that in the beginning the earth was a great cloud of dust and without form—a great whirling and swirling cloud of solid particles. We must pass quickly over this long period of gathering together of these myriads of particles to form the solid earth. Before life was able to subsist the earth grew by the addition of particles of solid matter and gases from without, while the great bodies of water, oceans and seas, and atmosphere grew by addition from within. As changes and readjustments occurred within the earth these have given water and air for the atmosphere, stratosphere, hydrosphere, lithosphere, and bathosphere. The loosely compacted solid particles, of which the earth is composed, have given the earth a great energy which has given us our hills, mountains, hemispheres, and continents. These, in turn, have been leveled by the processes of erosion.

Just as we divide present time into centuries, years, and months, so do geologists divide the ages of the earth into longer and shorter periods. Geologic time, like astronomic space, is very great when compared with human experience. Centuries are as the tick of a watch in geologic time. Eons of time are required to explain geologic history and geologists recognize five great eras of time and each is longer than the succeeding era.

All of the coal fields of southeastern Kansas were formed during the third era. (The large divisions of time are called eras, and each era is divided into periods.) The names of these divisions indicate some prominent characteristics, or their order of occurrence. Beginning with the most recent or Cenozoic era, the time of "recent or modern life," the accepted length in years is 60 million; the next or fourth era, Mesozoic, is the time of middle life, with a length of 140 million years; the third era, Paleozoic, or time of "old or early

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life," endured for 400 million years; the second era, Proterozoic or time of "earlier or former life" lasted about 900 million years; and the first, Archeozoic, "ancient life," formerly believed to be without life but now conceded as representing the time of the oldest known rocks during which there were beginnings of life, lasted about 500 million years. Hence, we have a total of 2500 million years or more for geologic time.

The question might arise as to how this conclusion is derived. When we have a great thickness of rock layers amounting to over 500,000 feet it makes an impressive total. "The colossal hour-glass of rock destruction on the land and of rock formation on the sea-floor is unceasing." Several methods are used in calculating the length of past ages, but perhaps the most commonly accepted geologic timepiece is the radium bearing ores. It seems that the rate of disintegration of the radio-active elements can not be hurried up or slowed down; therefore, it may be assumed to have been the same throughout geologic time. The percentage of disintegration may be found by analyzing samples of these ores taken from rocks of the various ages. By knowing the rate of disintegration, the time elapsed from the formation of the rock may be easily figured.

It is difficult to understand the tremendous amount of time involved. In order to have a better understanding of the time involved, we will assume that one million years of geologic time is as a day in human experience With this time scale before us, the building of the coal fields of southeastern Kansas took place about eight months ago; the era of "middle life," or "the age of reptils," began about seven months ago. The age of fishes began about a year and a half ago; the dawn of life upon the earth happened about four years ago. It is estimated by some that the age of man began about 24 hours ago, and others say that he has occupied only eight minutes of geologic time.

In the earlier eras of geologic history, which began four or five years ago according to our geologic time calendar, we find these eras represented largely by sedimentary rocks which are made up of the muds and sands carried by rivers or other agencies and spread out in layers over basins of large or small extent, and later hardened by being buried under other sediments. In the southeastern section of Kansas there are numerous great systems of sedimentary beds. They consist largely of limestone, shale, and sandstone which were first spread out as oozes, muds, and sands on the floors of the ancient seas.

There is a story in each layer of rock. The ripple marks, the drying cracks, the stratification, the sorting and sizing of materials, the tracks of extinct animals, and the remains of plants and animals found in them show us the times and conditions surrounding their origin and subsequent history.

The earlier third era rocks of this region are largely limestone and shales, caused by a succession of quiet seas interrupted again and again by the withdrawal of the sea, and the consequent erosion of large parts of the sedimentary record. The fossils found in them are of great usefulness, not only in telling of the past climate and surroundings, but for distinguishing between them, as each system has its own life assemblage buried within.

At intervals during the closing stages of the third or Paleozoic era, vast forests flourished and their remains have been preserved in the form of great

coal beds. Fossil leaves found in the coal and adjacent beds reveal the former presence of many plants.

The early stages of coal formation were very important from an economic as well as a geographic point of view. When you leave your warm house on a cold winter morning and start off in your automobile, it is interesting to recall that the oil, natural gas, and coal of this region, which we all take as a matter of course, were in the process of formation many million years ago before the age of reptiles.

As the seas retreated and the land appeared, climatic and soil conditions were favorable for luxuriant vegetable growth, especially in swamps and marshes. After large amounts of plant material had accumulated, the land subsided, silt and sand were washed in, and a coal bed was finally formed. These processes were repeated many times and show plainly the many relatively upward and downward movements of the land in the early stages of growth. Eventually conditions changed, but we now have billions of tons of coal which were formed in the latter part of the Paleozoic time.

As great stresses were developed within the earth, the rock layers of the earth's crust began to warp and buckle and great dome or ridge shaped folds were formed. These became traps for oil and gas which had been forming for ages through the death, burial, and decomposition of myriads of plants and animals in the seas and swamps. Finally, due to prolonged intense earth movements, the seas were completely drained back into the oceans, and the central part of the United States was gradually uplifted.

Much of this history has been made known by the study of remains of plants and animals preserved in the rocks. The remains of organisms are what are known as fossils, the term being restricted today to the remains or indications of life of the past. The preservation of animal or plant parts requires that the organism upon death be protected from ravages of the elements. This is accomplished by the immediate covering by water, sand, mud, or any other substance that will exclude the chief agents of decay, air, and water. These conditions are met best in nature in the deposits made by streams, in lakes, and in shallow seas which periodically covered the lands. Consequently fossils are to be found only in great groups of rocks known as sedimentary (shales, sandstones, limestones). Rocks that have been materially changed by great pressure and heat, or as the result of volcanic action, are practically devoid of fossils.

Man has known and has been interested in fossils from very ancient time, but only within the last century and a half has their true nature and importance been recognized. Before the nineteenth century it was generally believed that the remains were either those of animals that had perished during the Biblical floods, a great catastrophe, or probably of animals that had once lived where the fossils were found, but had migrated to other parts of the earth. Discoveries and explorations showed that such was not the case and the present belief is that fossils are the actual remains of life of past ages.

Fossil remains are grouped into three classes: first, actual, unchanged parts such as the hair, skin, bones, shells, and sometimes flesh of animals and the woody fibres of plants; secondly, somewhat or completely changed hard parts of organisms; and last, mere traces or indications of life such as animal footprints, worm burrows, or in the case of man, arrows, utensils, and so on.

The first class is rare and has not been found to my knowledge in southeastern Kansas. You may have seen, and even wondered why some of the restorations of the elephants that once roamed over North America are shown with a heavy hair cover. These remains have been found in ice in different localities in Siberia and Alaska, which shows us not only the hair cover but every detail of the body structure. These cases are the first instance of preservation by cold storage; in this case it has been estimated that the specimens have been preserved for at least 50,000 years. Many other animal skeletons have been found in the tar pools of California, but in this case only the hard parts of the body remain. Insects have become embedded in the pitch of trees, the pitch was covered over, and the material has been preservd for thousands and thousands of years.

The second class, changed remains, includes the majority of known fossils. As soon as the plant or animal died and was covered, chemical changes began and gradually the circulating waters in the rocks removed the plant or animal tissue and left in its place compounds such as lime carbonate, iron sulphide, silica or other substances. One of the best examples is the familiar petrified wood.

The third class of fossils, indications, requires little explanation. If an animal walks across a mud flat, the mud dries and we have the prints ready for preservation if they are covered with sedimenet. The finding of arrowheads have been found in southeastern Kansas.

Since geologic history is divided into five eras, each of these had a more or less characteristic group of animals and plants to distinguish it. The first two eras were distinguished by very primitive life forms, the third, or Paleozoic, by many animals without backbones, the first fishes, primitive amphibians and reptiles, and the non-flowering plants; the fourth or Mesozoic had many land and water reptiles; the fifth, or Cenozoic, was characterized by warm-blooded mammals, modern trees, grasses, and flowers.

Many of the rocks of the first two eras have been changed through the millions of years so that most life records have been destroyed. Lime reefs similar to coral reefs and a few remains of sponges have been discovered in some parts of the United States but in the main these earliest rocks were devoid of fossils.

Conditions were much different during the third or Paleozoic era. The beds of today are not much changed from their original lime, sand, and mud. Many localities in southeastern Kansas have produced an abundance of fossils. Many of the animals that have been found in the older rocks are wholly extinct. One of the more prominent fossils through this entire portion of geologic time, is a rather unimpressive two-shelled form of fossil known as the "Lampshell" or Brachiopod. In general outline this prolific group resembles the clams but its body structure is quite different. Wherever Paleozoic beds occur, one may be sure some traces of these important types will be found.

Perhaps the most significant fact in connection with the life of the era is its great variety. Representatives of every one of the major groups of animals known (except the backboned animal vertebrates) have been described from even the earliest rocks of the era. If the development of life has been gradual,

this suggests that animals and plants must have been present for untold ages before this period.

Let us consider the life of the Paleozoic or third era more fully. The geologist divides the rocks of this era into seven distinct systems, each one of which has its own characteristic assemblage of fossils. We shall discuss only those up to and including the Carboniferous system because it was in this system that the coal fields of southeastern Kansas were formed.

The Cambrian, the first period of the Paleozoic era, is of special interest and importance because its rocks constitute the oldest system known that contains recognizable fossil forms. It is, therefore, the first satisfactory record of life. Most of the fossils represent the shells or tracks or marine animals buried in the sands and muds.

Among the invertebrates known to have existed are several kinds of mollusks, sea worms, sponges, a few forms of the protozoa group and corals. The highest in organization of the Cambrian animals was the trilobite. It is supposed that with the abundance of animal life there was a corresponding abundance of vegetable life, to furnish the needed food supply. Geologists also infer from the shells, plates and other forms of protective covering that animals became extremely complex and spiny.

In the next period, the Ordovician, the fossils are almost entirely those of marine invertebrates, but among them are the first remains of fishes. Among the most interesting are shelled forms distantly related to the octopus and squid of today. This division of the animal world is known as the Cephalopod or "head-footed" group, the name being derived from the development of tentacles, or feelers, about the head. Some of these grew to immense size, bearing shells up to fifteen feet long and a foot in diameter.

The Silurian period is marked by the formation of coral reefs, the first appearance of scorpions, and a rich and varied development of echinoderms. Fossils of land life continue to be meager, and likewise not so much is known of plant life of the sea.

The next period, the Devonian, has rock formations which are of importance commercially. In some parts of the United States the Upper Devonian is the chief source of oil and gas. During this period marine fishes were abundant, and there were sharks having fin-spines a foot in length. Barnacles of the modern sessile type made their first appearance. Plants, snails, insects, myriapods, scorpions and amphibians are known to have lived on the land, and Devonian period saw the origin of ferns and of the gigantic progenitors of horsetail rushes and club mosses. Fernlike plants predominated.

To the people of southeastern Kansas the next, the Carboniferous Period, divided into Lower and Upper Carboniferous, is an especially important epoch in geologic history from an economic standpoint. It is the second division, the Upper Carboniferous, that the rich coal measures of southeastern Kansas and many other states were formed.

From the Lower Carboniferous stage comes the earliest wood which shows rings, but the record of land life is as a whole inadequate.

Sharks were supposed to have been supreme in the open seas and were more abundant than in any later period. The record of land life of the Upper Carboniferous stage is unusually full. Gymnosperms were present in great numbers. Giant ancestors of the modern horsetails grew in the forest

to a height of sixty to ninety feet, and there was an abundant growth of huge club mosses and fernlike plants. Since coal is of vegetable origin, the coal measures bear wonderful records of the complex plant life of the Upper Carboniferous age.

Animal life in this stage of the world's history is also abundant. On the land lived amphibians, insects, spiders, scorpions, myriapods, and land snails. It is in the later coal measures that fossils of amphibians are first found in abundance and variety. Another important feature of the age was the development of fresh-water fishes; mollusks, and crustaceans.

Many other animal groups occur with these more important forms. Ancestral primitive clams and snails occur abundantly in some places. The oil-bearing formations of the Mid-Continent area are literally filled with single-celled animals, but for some reason, the waters of some seas were not especially favorable for their existence. It may be that the practical absence of petroleum in Paleozoic rocks in some regions is due in part, at least, to the absence of these single-celled, sometimes microscopic organisms, as they are known to be prolific sources of petroleum in other regions.

A great interior sea covered most of the present plains and prairies. We know that the sea remained over this region for a long time, because we can find wide-spread deposits of shale, sandstone, and limestone, thousands of feet thick, which contain many remains of marine, plant and animal life of this stage. The retreating sea was the last of six or seven great Noah's floods that had covered this part of the continent. However, we must remember that this particular flood occurred many millions of years before Noah built his ark.

The coal fields of southeastern Kansas were formed during the Upper Carboniferous stage of the Paleozoic era more than 185 million years ago, but the value of the various deposits of materials is just beginning to be appreciated.

BIBLIOGRAPHY

Abernathy, G. E. 1938. Cyclical Sedimentation of the Cherokee: Kansas Acad Sci. Trans., vol. 41, pp. 193-197.

Greene, F. C.. 1933. Oil and gas pools of western Missouri: Missouri Bur. Geol. and Mines, 57 Bien. Rept., App. 2, pp 5-68,

Haworth, Erasmus. 1895. The coal fields of Kansas: Kansas Univ. Quarterly, vol. 3, no. 4, pp. 297-309.

Haworth, Erasmus, and Crane, W. R. 1898 Special report on coal: Kansas Univ. Geol. Survey, vol. 3, pp. 1-336.

Landes, K. K. 1937. Mineral resources of Kansas counties: Kansas Geol. Survey, Min. Res. Cir. 6, pp. 1-102.

Moore, R. C., and Landes, K. K. 1927. Underground resources of Kansas: Kansas Geol. Survey Bull. 13, pp. 1-147.

Moore, R. C. 1929. Kansas coal fields: U. S. Bur. of Mines Tech. Paper 445, pp. 3-7.

Pierce, W. G., and Courtier, W. H. 1937. Geology and coal resources of the southeastern Kansas coal fields in Crawford, Cherokee, and Labette Counties: Kansas Geol. Survey Bull. 24, pp. 1-122.

Young, C. M., and Allen, H. C. 1925. Kansas coal: Kansas Univ Bull., vol. 26, no. 5, pp. 1-202.

Etadonomys, A New Pleistocene Heteromyid Rodent, and Notes on Other Kansas Mammals

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ABSTRACT:—*Etadonomys tiheni,* gen. et sp. nov. is reported from the Borchers fauna and *Microtus (Pedomys) ochrogaster* (Wagner) is reported from the Jones fauna, Meade County, Kansas. *Euceratherium* is reported from the Pleistocene of Kansas.

INTRODUCTION

During the past three summers a number of fossils have been collected in southwestern Kansas from scattered localities by the Kansas University Museum field parties and members of the United States Geological Survey, Division of Ground Water. These specimens have added to our knowledge of the Pleistocene mammals of that area and are considered worthy of being placed on record.

I am grateful to Mr. S. W. Lohman, Geologist in charge, and the staff of the Division of Ground Water, United States Geological Survey, for their cooperation in reporting vertebrates which they have found; also to Dr. H. H. Lane, Director of Kansas University Museum for helpful criticism and Dr. R. A. Stirton, Curator of Vertebrate Paleontology, Department of Paleontology, University of California, for the examination of specimens under question; we are indebted for the cooperation and courtesies extended us by Messrs. Lee Larrabee, Guy D. Josserand, Leonard Sutherland and Harry Smith, of the Kansas State Forestry, Fish and Game Commission.

BORCHERS FAUNA

Among the material collected with the Borchers fauna in Meade County, is the ramus of a new heteromyid rodent. For the new rodent I wish to propose the name:

Etadonomys gen. nov.

GENOTYPE—*Etadonomys tiheni* sp. nov., No. 6461, Kansas University Museum of Vertebrate Paleontology; incomplete left ramus with alveoli of P_4, in part, and M_1-M_3.

DIAGNOSIS.—A heteromyid the size of *Dipodomys ordii richardsoni* (Allen). P_4 and M_1 each with two roots, M_2 and M_3 single rooted. A pit developed dorsally and labially to the mandibular foramen. M_3 not completely lingual to the mandibular foramen as in *Dipodomys.*

Etadonomys tiheni sp. nov.

Plate 1, figs. 5, 6, 7, 8, 9.

HOLOTYPE:—No. 6461, Kansas University Museum Vertebrate Paleontology; incomplete left ramus, collected summer of 1941 by Claude W. Hibbard and party. Referred material, right ramus, No. 6123, bearing P_4 M_1; right ramus, No. 6734 bearing P_4-M_1; and a left ramus, No. 6733, bearing P_4-M_1.

HORIZON AND TYPE LOCALITY.—Pleistocene, Meade formation, Locality No. 9, Meade County, Kansas, Borchers fauna.

DIAGNOSIS.—This heteromyid differs from other fossil and recent forms in the relation of the mandibular foramen and pit to one another and their relationship to M_3. The relationship of the mandibular foramen to M_3 is similar to that in *Liomys* but the foramen is much larger. The foramen enters the ramus posterior to and in line with the labial portion of M_3. Dorsal to the mandibular foramen is a well developed shelf which covers the labial side of the foramen. Labial to the shelf and next to the ascending ramus is a well developed broad groove which gives a pitted condition when viewed from above and is not found to exist in other forms. P_4 and M_1 with two roots. M_1 with a larger transverse diameter than P_4. P_4 about equal in size with M_2. M_3 reduced and offset to lingual side. M_2 and M_3 single rooted.

DESCRIPTION OF TYPE.—The ramus is not complete, lacking the anterior portion and most of the alveolus of P_4. The roots of M_1 and M_2 are still in the alveoli. M_3, the smallest tooth, is shifted lingually. The root of this tooth is more nearly perpendicular than the root of M_3 in *Dipodomys* or *Prodipodomys*. The capsular process for the reception of the base of the incisor is more prominent than that of *Dipodomys ordii* though its relationship to the angular process is more like that found in *Dipodomys* than in *Liomys, Perognathus* or *Microdipodops*. Depth of ramus at M_3, measured on labial side is 4.2 mm.

This species is named for Joe A. Tihen who spent a number of years collecting fossils for the University Museum.

In the collection are three fragmentary rami referred to this form on the basis of size. The posterior part of the rami are missing. The process for the attachment of the masseteric muscle is not as strongly developed as in *Dipodomys ordii* nor does it extend as far forward in front of P_4 as in *O. ordii.* The mental foramen is the size of that in *D. ordii* though slightly closer to P_4. The antero-posterior diameter of P_4-M_1 in specimen No. 6123 is 2.6 mm.; No 6734, is 2.55 mm.; and No. 6733, is 2.6 mm.

The following mammals have been found associated with *Etadonomys tiheni*:

ORDER INSECTIVORA
- *Sorex taylori* Hibbard

ORDER CARNIVORA
- *Canis* sp.
- *Mustela* sp.
- *Spilogale* cf. *leucoparia* Merriam
- *Felis?* sp.

ORDER RODENTIA
- *Citellus meadensis* Hibbard
- *Citellus cragini* Hibbard
- *Geomys* sp.
- *Perognathus pearlettensis* Hibbard
- *Perognathus gidleyi* Hibbard
- *Onychomys fossilis* Hibbard
- *Reithrodontomys pratincola* Hibbard
- *Sigmodon hilli* Hibbard
- *Parahodomys* sp.
- *Synaptomys* cf. *vetus* Wilson

Ondatra sp.
Zapus burti Hibbard
ORDER LAGOMORPHA
Nekrolagus sp.
Hypolagus sp.
Lepus cf. *californicus* Gray
ORDER PERISSODACTYLA
Equus sp.
ORDER ARTIODACTYLA
Camelops sp.
A small antilocaprid.

For a complete discussion of the above mammals see Hibbard 1941 and 1942.

JONES FAUNA

In the past three summers remains of fossil *Microtus* have been recovered in scattered localities in Meade County. One specimen is of particular importance since it was found in association with the Jones fauna.

Microtus (Pedomys) ochrogaster (Wagner)

Plate 1, fig. 2.

A right ramus, No. 5191, referred to the above form was taken from Locality No. 13, Meade County, Kansas. It is smaller than specimen No. 5971, (Pl. 1, fig. 4) collected by Tihen on the XI Ranch in the breaks of the Cimarron River. The specimen compares in size with *M. o. minor* (Merriam). M_1 consists of a posterior loop, three alternating tightly closed triangles, with the fourth and fifth triangles confluent and opening into the anterior loop. M_2 consists of a posterior loop, the first and second triangles tightly closed and the third and fourth confluent. The anteroposterior diameter of M_1-M_2 is 4.25 mm.

This specimen has a tooth pattern the same as that of *Pitymys* and may belong to that genus.

The forms found associated with *Microtus (Pedomys) ochrogaster* are:

AMPHIBIA
Ambystoma tigrinum (Green)
MAMMALIA
Order Insectivora
Sorex cinereus Kerr
Order Carnivora
Mephitis mephitis (Schreber)
Taxidea taxus (Schreber)
Order Rodentia
Citellus richardsoni (Sabine)
Citellus tridecemlineatus (Mitchill)
Cynomys ludovicianus Ord
Geomys sp.
Perognathus sp.
Onychomys leucogaster (Wied)
Peromyscus sp.
Microtus pennsylvanicus (Ord)
Order Artiodactyla
Platygonus sp.

EXPLANATION OF PLATE

Fig.

1. *Euceratherium* sp., No. 6686 KUMVP, left M_3, lateral and occlusal views. X1.
2. *Microtus (Pedomys) ochrogaster* (Wagner), No. 5191 KUMVP, right M_1-M_2, occlusal view. X10.
3. *Microtus pennsylvanicus* (Ord), No. 6494 KUMVP, right M_1-M_2, occlusal view. X10.
4. *Microtus (Pedomys) ochrogaster* (Wagner), No. 5971 KUMVP, left M_1-M_2, occlusal view. X10.
5. *Etadonomys tiheni,* No. 6123 KUMVP, right P_4-M_1, occlusal view. X10.
6. *Etadonomys tiheni,* No. 6733 KUMVP, left P_4-M_1, occlusal view. X10.
7. Referred left P^4-M^1, to *Etadonomys,* occlusal view. X10.
8. *Etadonomys tiheni,* No. 6734 KUMVP, right P_4-M_1,occlusal view. X10.
9. *Etadonomys tiheni,* holotype, No. 6461 KUMVP, fragmentary left ramus, lateral view. X10.

PLATE I

For a more detailed description of this fauna see Hibbard, 1940, 1942, and Tihen, 1942.

Microtus pennsylvanicus (Ord)

Plate 1, fig. 3.

A right ramus, No. 6494, bearing M_1-M_2 was found in association with fish, amphibia and turtle remains, at Locality No. 7, XI Ranch, Meade County, Kansas The size of the ramus and the anteroposterior diameter of the teeth are larger than those of the specimen from the Jones fauna of Meade County though the crown pattern is the same. The anteroposterior diameter of M_1-M_2 is 5.2 mm. This specimen is of special interest since it was taken at Smith's (1940, p. 102) Locality B. It was taken from bed 3 or 4, of Smith's measured section just up the gulch on the south side from the site where the specimen of *Aenocyon dirus* (Leidy) was recovered. These beds are well up in the Pleistocene section and appear to be above the "High Terrace" sand and gravel along the present Cimarron valley. The 75 to 100 feet of sand and gravel reported by Smith as underlying these deposits are considered to be the "High Terrace" deposit which has been greatly distorted due to the development of a large sink or a series of sinks in that area. It appears that the beds overlying the terrace deposit were laid down in a depression and were later distorted by the further collapse of the underlying beds.

Down the gulch about a quarter of a mile, on the west side, is a much younger valley deposit which may be early Recent that contains numerous invertebrates. It was from this deposit that Joe Tihen collected a right ramus of *Microtus (Pedomys) ochrogaster* (Wagner), No. 5971 (Pl. 1, fig. 4) in 1940. The ramus bears M_1 and M_2 which have an anteroposterior diameter of 5.2 mm. It is impossible to separate it from the genus *Pitymys,* since it is the size of the recent *Pedomys* occurring in that area, it is referred to that form until more material is available for study.

Euceratherium sp.

Plate 1, fig. 1.

Doctor Thad McLaughlin, of the U.S. Geological Survey, while working on the ground water of Grant County, Kansas, collected a LM_3, No. 6686, which is referable to the above genus from the Sullivan gravel pit in the SW¼ of sec. 7, T. 29 S., R. 37 W. This tooth was sent to Dr. R. A. Stirton for identification and his comment is as follows, "This third lower molar differs from that in camels in that the tooth curves labially. It is similar in all details with the specimens of *Euceratherium* from Potter Creek and Samwell Caves in California." The anteroposterior diameter of the tooth is 38.25 mm. Found associated with the LM_3 is the molar of a fossil horse referred to *Equus* cf. *niobrarensis* Hay.

The remains of musk-oxen from the Pleistocene of Kansas are rare. A skull in the American Museum of Natural History (No. 12699) that came from near Wilson, Kansas, is considered as *Symbos* cf. *cavifrons* (Leidy). For further discussion of this specimen see Frye, Leonard and Hibbard, 1943, p. 45. There is a base of another musk-ox skull in Mr. George Sternberg's collection in the museum at the Fort Hays Kansas State College. Mr. Sternberg said that it was taken in the vicinity of Hays, Kansas, years ago, and that the locality and horizon is unknown.

Euceratherium bizzelli Stovall (1937) was described from the base of a cranium possessing complete horn cores taken from a sand and gravel pit at Hydro, Caddo County, Oklahoma. Barbour, 1931, in his discussion of the musk-oxen of Nebraska reports no remains of *Euceratherium* have been found in Nebraska. The distribution of this genus, east of the Rocky Mountains, is poorly understood. Gazin (1933) questions the identification of specimens from Illinois and Maryland as *Taurotragus* and believes these specimens are probably related to the *Preptoceras-Euceratherium* group.

LITERATURE CITED

BARBOUR, ERWIN HINCKLEY. 1931. The Musk-Oxen of Nebraska. Nebr. State Mus. Publ., vol. 1, bull. 25, pp. 211-233, 15 figs.

FRYE, JOHN C.; LEONARD, A. BYRON and HIBBARD, CLAUDE W. 1943. Westward Extension of the Kansas "Equus Beds." Jour. Geol., vol 51, no. 1, pp. 33-47, 3 figs.

GAZIN, C. LEWIS. 1933. The Status of the Extinct American "Eland." Jour. Mamm., vol. 14, no. 2, pp. 162-164.

HIBBARD, CLAUDE W. 1940. A New Pleistocene Fauna from Meade County, Kansas. Trans. Kans. Acad. Sci., vol. 43, pp. 417-425, 2 pls.

———. 1941. The Borchers Fauna, a New Pleistocene interglacial fauna from Meade County, Kansas. Kansas Geol. Survey Bull. 38, pt. 7, pp. 197-220, 2 pls.

———. 1942. Pleistocene Mammals from Kansas. Kansas Geol. Survey Bull. 41, pt. 6, pp. 261-269, 1 pl.

SMITH, H. T. U. 1940. Geological Studies in Southwestern Kansas. Kansas Geol. Surv. Bull. 34, 212 pp., 22 figs., 34 pls.

STOVALL, J. WILLIS. 1937. *Euceratherium bizzelli*, a new ungulate from Oklahoma. Jour. Paleo. vol. 11, no. 5, pp. 450-453, 3 figs.

TIHEN, JOE A. 1942. A Colony of Fossil Neotenic *Ambystoma tigrinum*. Univ Kans. Sci Bull., vol. 28, pt. 2, no 9, pp 189-198, 2 figs.

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Experimental Application of Hypnosis

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The central aim of this paper is to point out the gradually changing status of hypnosis in psychological experimentation and to discuss briefly the kinds of problems for which a hypnotic technique seems most promising. Even if one is willing to neglect the early history of hypnosis and to consider its scientific existence as of the last twenty years, one cannot help but be impressed by the trend. During these two decades, over five hundred articles and books have been written on hypnosis. However, only a third of these was written during the first half of this twenty-year period while two-thirds were written during the past ten years.

This great increase in the volume of hypnotic investigations has brought with it a striking shift in the kinds of problems explored. Whereas earlier researches concerned themselves with the accumulation of isolated bits of information about hypnosis, contemporary investigations are more substantially related to the mainstream of psychological research. The "so-what?" feeling, which frequently met the earnest efforts of early investigators in this field, was simply a reflection of the fact that hypnotic experimentation seemed to be a fascinating trip to a dead-end street. Critics complained, with justification, that it hardly mattered whether a subject in hypnosis could judge the passage of time more accurately than normal-state subjects. Similarly, the attempts to characterize the nature of the hypnotic state itself were equally academic and fruitless. The concept of "suggestion" or that of "dissociation" did little more than provide screens for our essential ignorance of the process. All this is not to say that the recent studies have completely broken with this tradition, nor is it to say that we now have the crucial data regarding the nature of hypnosis. It is rather that we have begun to recognize the importance of using hypnosis as a tool of research rather than as a curiosity for students in classes of abnormal psychology.

From an expanding field, we have selected several problems of recognized importance which have been studied with the aid of hypnosis. The first of these to be discussed raises a question with which every conscientious psychologist has confronted himself: "What is the place of psychoanalytic theory in a sound science of psychology?" In order to answer this question, the trained psychologist has asked for experimental data to extend or contradict clinical observations. He asks to be shown the specific significance of slips of the tongue, of dream symbols. He asks that it be demonstrated statistically that there exists a significant relationship between emotions and memory.

The clinician has replied that by their very nature these problems cannot be studied in the laboratory because one cannot create emotions sufficiently intense or genuine to parallel the conditions of life. It is not our intention here to offer proof or disproof of any of these controversial problems, but only to illustrate techniques of investigation.

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Erickson has recently illustrated the use of hypnosis in investigating what Freud called "the psychopathology of everyday life." His method was to suggest to a subject in a deep trance that in the normal state he would recall as his own an experience suggested by the hypnotist. Frequently, the suggested experience was one which the subject would normally try to conceal. Then when the subjects were brought back to the normal state, they were acutely aware of the suggested experience, but as a real memory and not as a post-hypnotic suggestion. In their efforts to evade discussion of this memory, Erickson demonstrated striking instances of slips of the tongue and erroneously executed actions similar to those observed clinically and clearly referable to the implanted suggestion. In one instance, the suggestion was given to a subject that in the following normal state, he would be bored by the current conversation but would try to conceal his boredom. In the course of abortive attempts to interrupt the conversation the subject made several slips of the tongue which seemed unambiguously related to the post-hypnotic suggestion. Erickson describes it as follows:

> "Finally he interrupted Dr. D., saying, 'Excuse me, I feel an awful draft,' and got up to close the door. As he did so he was asked what he was doing. He replied, 'The air seems to be awful hot ('hot air!'); I thought I would shut off the draft.' When the hypnotists pretended not to understand and asked him what he was doing the subject replied, 'Why, I just shut the bore.' His remark was then repeated by the hypnotist for the benefit of those in the audience who had not heard it. When the subject heard his statement given as 'shutting the bore' he started visibly, seemed tremendously embarrassed, and with much urgency turned to Dr. D. saying, 'Did I say that? I didn't mean that I just meant I closed the door' He was apologetic in his whole manner and bearing."

In my own experiments of this type, I have used a similar technique. For example:

> "In one instance, a somnambulistic subject was instructed in hypnosis that upon returning to her normal state she would falsely recall having had a dream the night before in which a specific green pencil had played such a role as to frighten her deeply. In the posthypnotic state, she had occasion to write her name and address for which purpose the experimenter proffered the green pencil. She demurred, saying she had a pencil. When it appeared that she did not, the experimenter again extended the green pencil. The subject put out her hand and grasped the pencil so awkwardly that it immediately fell to the floor. The experimenter picked it up and once more gave it to the subject She took it and began to write her name: however, she pressed so hard that the point broke, rendering the pencil unfit for further use. The subject left the room and borrowed a new pencil although she might easily have sharpened the old one."

Although such experiments are perhaps suggestive, they are still extremely crude; and they have been offered only as illustrations of a general method.

Another challenging and relatively unexplored field is that dealing with dreams and their significance. Here again, there exists a great body of clinical material but very few experimental investigations. The first attempts to study dreams experimentally with the aid of hypnosis were made by Karl Schrotter in 1912. He would suggest to the subject in hypnosis that he dream a specific experience and would then observe the subject's choice of symbols in representing the suggested content. Although his preliminary findings were extremely suggestive, this type of hypnotic research was not pursued, probably

because of existing prejudices. Recently this technique has again been revived, but most of the reports are yet unfinished or unpublished.

In a study by Farber and Fisher, a group of students ranging in age from 18 to 21 were used as subjects. After being interviewed by the two psychiatrists, those students were chosen who proved to be naive in psychological matters and ignorant of any sort of theory. Many kinds of problems were investigated but the most striking, perhaps, are the attempts to show that a subject in hypnosis is somehow better able to translate the language of a dream than in the normal state. The authors say:

> "In order to examine what understanding our young subjects might have for the dream language under hypnosis, we presented them, at the onset of the project, with a variety of dreams. Some we manufactured ourselves; some were produced during hypnosis by the subjects; some were night dreams of friends and patients. These included most of the familiar symbols. In addition, a few myths and psychotic productions were used as dream material.
>
> "The dreams were presented quite directly to the subjects. For example, an 18-year-old girl was told under hypnosis: 'Dreams have meaning Now that you are asleep you will be better able to understand what they mean. A girl dreamt not so long ago that she was packing her trunk when a big snake crawled into it. She was terrified and ran out of the room. What do you think the dream means?' Almost before the question was finished, the subject blushed, hesitated a second, then remarked, 'Well, I guess she was afraid of being seduced."

She elaborated this interpretation, explaining the snake and the trunk as symbols.

Before being hypnotized, the subject had been asked the same question about this dream and had shown no response. As a control measure, subjects were always asked about a particular dream before and after hypnosis, and the authors stress that in no instance did the subjects in the waking state make any comment comparable to that obtained under hypnosis. Special precautions were always taken not to ask leading questions and an effort was made to phrase the questions in precisely the same way to each individual in both the waking and trance states.

The authors admit the tentative status of their inquiry and say, "It would be unfortunate to give the impression that dreams are like mathematical puzzles which have only one answer . . ." They conclude only that a method for studying the problems of dream psychology is suggested.

Another area which seems especially amenable to investigation by hypnotic techniques is that referred to generally as "psychosomatic phenomena". The findings reported here are so startling that a recent reviewer of the literature properly registers a plea for rigid control experiments. There are reports of acute alcoholic intoxication being made to disappear by direct hypnotic suggestion, or again to prevent its appearance if enough alcohol to intoxicate is drunk as "water". Dunbar, in her recent book on emotions and bodily changes, has discussed the earlier work of Heyer, who set out to establish proof of "psychic secretion in man". She describes the technique as follows:

> "Individuals having been carefully examined and found to have healthy gastrointestinal tracts were hypnotized. In deep hypnosis a fine sound was introduced into the stomach of these subjects, they knowing nothing about the experiment. The "empty" stomach content

was first pumped out. If after this no secretion occurred for 10 minutes, the subject was given the suggestion of taking a cup of bouillion, a slice of bread or a glass of milk. Swallowing was prevented by hypnotic command, and the saliva flowed out of the mouth. After the latency period (uniformly reported by observers in this field) of two to ten minutes, there was always a plentiful flow of juice through the sound. The juice was collected every five minutes and examined as to quantity, acidity, and albumin digestive potency. The absolute quantity seemed to correspond to the vividness of the suggestion as it was received. The curve was entirely different, according to which food had been suggested, just as in Pawlow's findings with dogs."

When the gastric secretion was well under way, these subjects were presented successively with vivid affects: fear, fright, and worry on the one hand; and joyful expectation on the other. These affects regularly disturbed the flow of gastric juice, irrespective of their euphoric or dysphoric nature. When the disturbing hypnotic suggestion was retracted, in time the secretion usually began again.

Even more striking in this connection are the experiments of Heilig and Hoff. One group of subjects was given the suggestion in hypnosis that they were eating a certain food, first with relish, then with disgust. A food was chosen for the suggestion which elicited from the subject no particular response in the normal state. They found that when the subject experienced pleasure in connection with the food, the acidity of the gastric secretion was increased; disgust decreased acidity Furthermore, the effect of disgust was much more marked than that of relish.

In the second series the same food was suggested to two different subjects with opposite attitudes toward it. It was one subject's favorite dish in the normal state, whereas the other had an "unconquerable aversion" for it. The authors found that suggestion of a favorite dish resulted in hyperacidity in an individual whose acid secretion was otherwise normal or subnormal, even if this dish were for example very fatty, and ought to be expected to inhibit secretion.

These and other psychosomatic studies strongly suggest that processes normally controlled by the autonomic nervous system may be experimentally manipulated in hypnosis to the end of discovering important relationships between psychological and physiological phenomena.

One of the most challenging and potentially useful of the hypnotic techniques is that of experimental "regression". The subject is told in hypnosis to return to an earlier age-level in his total orientation. In this way, granting the genuineness of the regression, a developmental process may be studied in retrospect. For example, we regressed O.W., a female subject aged 29, to an 8-year level. She was then given a Rorschach test which was later compared with the results of a Rorschach given her in the normal state.* Her responses in the normal state reveal an extremely inhibited, stereotyped, yet "impulse-ridden" individual with no movement responses. In contrast to this, the protocol taken in the regression at the age of 8 included four movement responses; she appeared to be a well-endowed, emotionally adaptive but extremely anxious child. It seemed that the repression of the creative abilities and of the free display of emotions came about concomitantly with

*The analysis of the results of both of these tests was made by Dr. David Rapaport.

the processes directed toward disposing of the overwhelming childhood anxieties.

In conclusion, we should like to state that we are fully aware of the manifold difficulties inherent in the investigation of all of the problems mentioned in this paper and we do not maintain that hypnosis will magically clear them away. "The potentialities of this little-understood phenomenon have not even begun to be investigated. Yet it appears that certain kinds of problems have been attacked most successfully by experimenters who have employed hypnosis and that hypnosis holds the greatest promise for their further systematic investigation. It would seem that the peculiarly strong affective relationship built up between an experimenter and a deeply hypnotized subject makes possible the creation and control of psychological phenomena far stronger than is possible by the use of orthodox laboratory methods." It is for this reason that we call this research tool to your attention.

BIBLIOGRAPHY

BRENMAN, MARGARET. Experiments in the Hypnotic Production of Anti-Social and Self-Injurious Behavior. *Psychiatry,* Vol. 5, No. 1, February 1942

———. Attempts at Experimental Substantiation of Psychoanalytic Theory. *Bulletin of the Menninger Clinic,* Vol. 6, No. 2, March 1942

BRICKNER, RICHARD M. and KUBIE, LAWRENCE S. A Miniature Psychotic Storm Produced by a Superego Conflict Over Simple Posthypnotic Suggestion. *Psychoanalytic Quarterly,* 5, 1936, 467-87

DEUTSCH, FELIX. Experimental Studies in Psychoanalysis. *Internat. Ztschr. f. Psychoanalyse,* 1923

EISENBUD, JULE. Method for Investigating Effect of Repression on Somatic Expression of Emotion in Vegetative Functions: Preliminary Report. *Psychosomatic Medicine,* Vol. 1, 1939.

ERICKSON, MILTON H. Experimental Demonstration of the Psychopathology of Everyday Life. *Psychoanalytic Quarterly,* Vol. 8, 1939

———. Hypnotic Investigation of Psychosomatic Phenomena · I. Psychosomatic Interrelationships Studies by Experimental Hypnosis. II Aphasia-Like Reactions from Hynotically Induced Amnesias (with Richard M. Brickner). III. A Controlled Use of Hypnotic Regression in the Therapy of an Acquired Food Intolerance. *Psychosomatic Medicine,* Vol 5, No. 1, January 1943

An Experimental Investigation of the Possible Anti-Social Use of Hypnosis. *Psychiatry,* Vol. 2, 1939

FARBER, LESLIE H. and FISHER, CHARLES. An Experimental Approach to Dream Psychology Through the Use of Hypnosis. *Psychoanalytic Quarterly,* Vol. 12, 1943

FREUD, SIGMUND. The Interpretation of Dreams. London: Allen & Unwin, 1932.

HEILIG, R. and HOFF, H. Uber psychogene enstehung des herpes labialis *Med Klin.,* Vol. 24, 1928

HEYER, G. R. Das körperlich-seelisch Zusammenwirken in den Lebensvorgängen, an Hand klinischer und experimenteller Tatschen dargestellt. München: Bergmann, 1925

HUSTON, PAUL E., SHAKOW, DAVID, and ERICKSON, MILTON H A Study of Hypnotically Induced Complexes by Means of the Luria Technique. *Journal of General Psychology,* Vol. 11, 1934

KLEIN, DAVID BALLIN. The Experimental Production of Dreams During Hypnosis. University of Texas Bulletin No. 3009, March, 1930

LURIA, A. R. The Nature of Human Conflicts or Emotion, Conflict and Will: An Objective Study of Disorganization and Control of Human Behavior. Philadelphia: J. B. Lippincott Co. 1942

NACHMANSOHN, M. Über experimentell erzeugte Träume nebst kritischen Bermerkungen uber die psychoanalytische Methodik (vorläufige Mitteilung.) *Ztschr. ges. Neur. Psychiat.* Vol. 98, 1925

RAPAPORT, DAVID. *Emotions and Memory.* Baltimore: Williams and Wilkins, 1942

ROFFENSTEIN, G. Experimentelle Symbolträume: ein Beitrag zur Disjussion über die Psychoanalyse. *Ztschr. ges. Neur. Psychiat.* Vol. 87, 1942

SCHROTTER, KARL. Experimentelle Träume, *Zentralblatt f. Psychoanalyse,* Vol. 2, 1912

SEARS, ROBERT R. Survey of Objective Studies of Psychoanalytic Concepts, A Report Prepared for the Committee on Social Adjustment of the Social Science Research Council, October, 1942

WELCH, LIVINGSTON. The Space and Time of Induced Hypnotic Dreams. *Journal of Psychology,* Vol. 1, 1936

26

Mental Work Blocks and the Galvanic Skin Response

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An important aspect of the study of mental work and fatigue is the relation of the concomitant physiological processes and the mental work processes. The central problems of such a study are whether, and in what manner, the concomitant physiological processes reflect the mental performance decrement, and whether the concomitance is coincident or causally related. A specific problem is the study of the physiological processes which occur at the time of momentary faltering of the mental work processes.

The so-called mental block, which makes its appearance as a momentary slowing up of work performance, is accompanied by physiological reactions which often observably change at the incidence of blocking. The galvanic skin response is a physiological reaction which often occurs during mental work blocking. What is the relationship between the mental block phenomenon and the galvanic skin response?

The most outstanding phenomenon of continuous mental work is the work efficiency decrement. Second in objectivity and importance is the fluctuating variation of mental work efficiency, the involuntary failure of the responding mechanism of mental work in maintaining a constant efficiency. Fluctuating variations in mental work efficiency are manifested in changing facility of responding to the task of the mental work. Involuntary blocks or block periods appear in rather regular order meshed in between normal and heightened efficiency. The blocks appear as slower responses and may appear as a single-slow response or as a group of slow responses following and followed by normal responses. The phenomenon of blocking has been extensively studied by Bills. (3). The causal mechanism of blocking is probably refraction of the response neuro-behavior system, as suggested by Bills. The vague term neuro-behavior system is here used because we do not know the exact nature of the causal mechanism. However, as Bills (1) has demonstrated, blocking occurrence is influenced by changes in the subject's available oxygen supply. This chemical relationship suggests that blocking and nervous refraction are similar in action.

Some light may be cast upon the causal mechanism of blocking by a study of the autonomic nervous system changes occurring during blocking. The autonomic changes may be partially reflected in the occurrence of the galvanic skin response, a sweat gland phenomenon mediated through the para-sympathetic system. To this end, a study was made of the relation of the occurrence of G.S.R.s and blocks or block periods.

METHOD AND PROCEDURE

The present study is a phase of a larger study, of which other phases have been previously reported (5, 6). Several physiological processes were observed by means of a Behavior Research Photopolygraph designed by Darrow (4). The process of interest in the present study is the galvanic skin response which was constantly recorded under all experimental situations. The elec-

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trodes used were the conventional zinc-kaolin-paste-zinc-sulphate type making palmar and volar (left arm) contact. The skin conductance level and G.S.R.s were read directly from the bromide paper. Conductance changes (G.S.R.s) of 250 ohms and greater were recorded as significant in this study.

The mental task was color naming by manual response. The Bills psychergometer was used (2). The colors, five in number, were randomly presented, each color having a corresponding key which the subject pressed when the color appeared. The manual response to the color in view automatically brought up the next color. The colors were red, green, yellow, blue, and white. The subject could respond as fast as he was able without error. Errors were not recorded. The subjects practiced for accuracy and speed. After the subjects attained a proficiency of about 90 colors per minute they were subjected to the experimental conditions. No subject participated in the experiment until his curve of learning progress asymptoted.

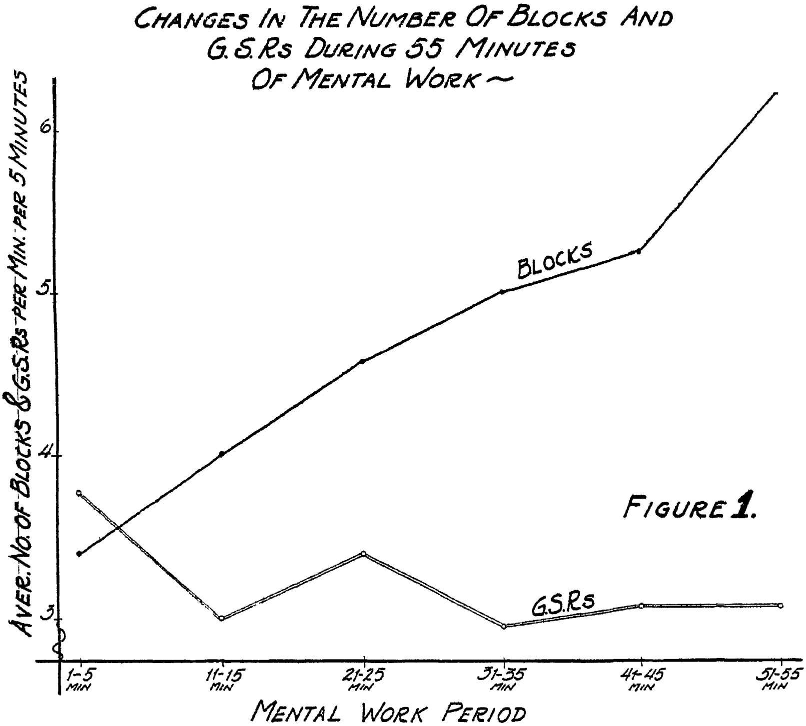
The color naming response was recorded on the same bromide paper as the recorded physiological reactions. The blocks and G.S R.s were counted and tabulated The criterion of a block was a response which was twice the time of the median of the surrounding normal responses. Some subjectivity entered in block evaluation since a rigid criterion would have some responses unaccounted for; e.g, the fanning out of responses with increasing and then decreasing reaction times, an obvious case of faltering and refracting response, and also the occasional appearance of series of responses that are quite fast, then a break by a single, or couple of slow responses, and again a resumption of speed. The number of G.S.R.s associated with blocks and the number of blocks associated with G.S.R.s were tabulated for each five minutes of mental work. The criterion of association or "coincidence" was a block or blocks occurring within five seconds of the incidence, during, and eight seconds after the incidence of a G. S. R. The average G.S.R. reported is about eight seconds long and occurs within three to five seconds after the stimulus. A separate tabulation of the blocks was made which occurred within one to five seconds of the incidence of a G.S.R.

The number of blocks, G S.R.s, blocks associated with G.S.R.s, and G.S.R.s associated with blocks for each five-minute period for each day of work were added together. The percentage of the total number of blocks associated with G.S.R s and the percentage of the total number of G.S.R.s associated with blocks were determined for each five-minute period for each subject. The number of blocks, number of G.S.R.s, the per cent of blocks associated with G.S.R.s, and the per cent of G.S.R.s associated with blocks were averaged for all the subjects for each five-minute work period. These averages were plotted against the period of work time.

The subjects when under study were semi-reclined in a comfortable chair. They worked for 55 minutes, on four mental work days. Ten subjects participated in the experiment. Because of the expense of bromide paper, continuous records were made only for the five-minute periods of 1-5, 11-15, 21-25, 31-35, 41-45, and 51-55 minutes, inclusive.

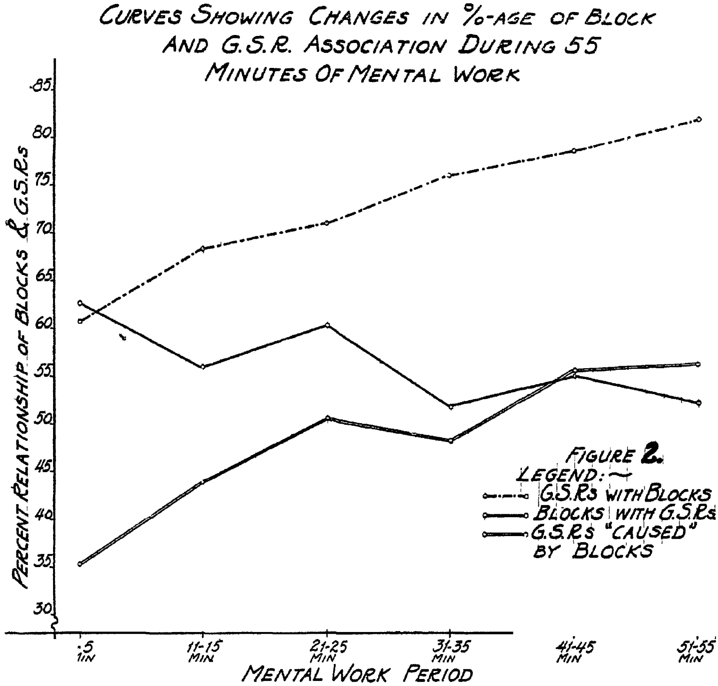
RESULTS: PRESENTATION AND INTERPRETATION

The criterion of mental fatigue is established by the progressive increase in the number of blocks occurring during the course of the mental work, as shown in Figure 1. There is about a 100 per cent increase in number of



blocks in the 51-55 minute period over the 1-5 minute period. The number of G.S R.s tends to slightly decrease during the course of the work, the decrease being at most about 18 per cent. The last half of the mental work period shows practically no change in number of G S.R.s. These changes in the frequency of blocks and G.S.R.s during the mental work must be considered in relation to the processes of block and G.S.R.s association. An attempt is made here to approach the problem of causal relationship in terms of "coincidence." The temporal definition of coincidence as here used places the problem on a broad basis. Later we shall attempt to describe the causal relation between blocks and G.S.R s more specifically.

The graphs of Figure 2 describe the relationship between the blocks and G S.R.s. The graphs describe the percentage of coincidence between the two phenomena. To further understand the plots of coincidence it must be recognized that there are a different number of G.S.R.s and blocks, and that several blocks may coincide with a single G.S.R., and more than one galvanic response may coincide with one block. Thus it was necessary to make more than one notation of the degree of coincidence of block and galvanic phenomena. Though there is but a slight and decreasing change in the number of G.S.R.s there is a considerable increase in the percentage of the number of G.S.R.s associated with blocks in the course of the mental work; while on the other hand there is an increasing number of blocks as work progresses, there is a decided decrease in the percentage of blocks associated with G.S.R.s. In other



words, there are more and more blocks occurring which are not associated with G.S.R.s as work progresses but the galvanic responses that do occur are accompanied more often by blocks. Thus it seems that with continued work the G.S.R.s become increasingly associated with blocks but the increasing number of blocks becomes less and less associated with galvanic changes. This apparently contradictory relation becomes clearer in the light of an assumption that there are two or more types of blocks—a galvanic block and a non-galvanic block; that is, one type of block associated with autonomic disturbance or such a disturbance reflecting the mental block, and another type of block free of autonomic disturbance. Thus as work progresses and fatigue sets in there are more and more blocks occurring which "reflect" no autonomic change (G.S.R.). (It should be noted that the two relationships of coincidence are probably in a large measure due to a "number factor." The increase in the percentage of G.S.R.s coincident with blocks may be due, in a large measure, to the increase in the number of blocks thereby providing increased probability of coincidence. The decrease in percentage of blocks coinciding with G.S.R.s may be due to the decrease in the number of G.S.R.s.) In any event, the G.S.R. is associated with some change in efficiency of mental work. Whereas in the early periods of work the G.S.R.s were not as frequently associated with blocks as in later periods of work, galvanic responses are found coincident with increases in efficiency, probably reflecting the need for a greater regimentation of energy in order to increase efficiency. This partially

accounts for the lower percentage of G.S.R.s to blocks in the earlier period of mental work. It would seem from this that galvanic responses become less and less associated with increased efficiency and more and more associated with decreased efficiency, the decreased efficiency becoming greater as work progresses. However, as work progresses, there is evidenced a greater number of blocks not associated with G.S.R.s. This phenomenon reflects something of the nature of the efficiency of the mentally working organism. After all, why should the organism become more over-wrought by a mere block by the release of autonomic activity (G.S.R.) each time a block occurs in an already fatigued state of the organism?

A question may be further asked as to what is the nature of those blocks which are associated with G.S.R.s and those which are not. This much is indicated by way of an answer. Primarily the large blocks and "block groups" are associated with G.S.R.s. The occasional block does not disturb the galvanic level. If the G S.R.s are a partial function of "attention" changes (Darrow), then we may conclude that as work progresses the blocks become less and less the result, or indications, of "shifts in attention" or shifts of autonomic regimentation of energy and more and more the result of faulty and inefficient operation of the implicit recognition processes.

In an effort to discern more specific causality than mere coincidence between the block and the G S.R. an examination was made to note the percentage of G.S.R.s which are preceded by blocks within 1 to 5 seconds of the galvanic change. Specific causality is assumed on the basis of temporal relation. This examination revealed that 48 per cent of the G.S.R.s are "caused" by blocks and that there is an increasing incidence of such "caused" G.S.R.s as work progresses. This percentage is sufficiently high to indicate a causal relationship, for the G.S.R. may be elicited by numerous other stimuli in the total mental work situation. Increases in efficiency, any considerable change in attention, atypical respirations, internal stimuli of various sorts—"mental" or physiological—extraneous laboratory stimuli, may and do elicit G S.R.s. In three of the subjects, atypical respirations were responsible for a good percentage of G.S.R.s. The evidence appears to be sufficient to say that the G.S.R.s are caused by stimuli inherent in the mental work, primarily the block.

What are the underlying conditions which make for causal relationship between blocks and galvanic skin responses? From earlier discussions of the interpretation of the level of skin conductance and galvanic skin response the causal conditions of block-stimulated G.S.R.s may be inferred. Any shift in attention results in a change in the level of skin conductance or a galvanic skin response. If the attention shift is momentary, a G.S.R. results superimposed upon the level of skin conductance which reflects the excitation background of the organism. If the attention shift is prolonged or attitudinal, the general level of skin conductance is elevated to a new level of excitation background.

A block is a momentary shift in attention in that it represents a "mental" pause of "recuperation." More exactly, it is a refraction of the response system. With each significant block the responding organism is brought to an abrupt condition of inadequacy of response. This condition entails a reorientation of effort or attention, a condition sufficient to bring into play additional

or changed autonomic excitation. Such a change in autonomic excitation produces a G.S.R.

Though a block is involuntary, its occurrence is usually accompanied by some degree of awareness. The blocks resulting in a fair degree of awareness are probably the galvanic blocks; while those blocks resulting in a lesser degree of awareness, or no awareness, are probably the non-galvanic blocks. The so-called non-galvanic blocks are blocks of lesser significance. In the earlier period of mental work, when the subject is more alert, there are fewer such non-galvanic blocks (note curve of G.S.R.s with blocks, Fig. 2); but as the subject becomes fatigued, the level of attention is depressed and more non-galvanic blocks occur. The non-galvanic blocks probably result from faulty recognition, incomplete learning integration, or, perhaps, dissociation resulting from general mental fatigue.

LITERATURE CITED

1. Bills, A. G. Blocking in Mental Fatigue and Anoxemia Compared. Jr. Exp. Psych. 1937, 20, 437-52.
2. Bills, A. G. A New Psychergometer. Jr. General Psych. 1936, 14, 487-89.
3. Bills, A. G. Some Causal Factors in Mental Blocking. Jr. Exp. Psych. 1935, 18, 172-85.
4. Darrow, C. W. The Behavior Research Photopolygraph. Jr. General Psych. 1932, 7, 215-19.
5. Geldreich, E. W. Skin Conductance Changes Occurring During Mental Fatigue. Trans Kansas Acad. Science, 1939, 42, 393-95.
6. Geldreich, E. W. Skin Conductance Changes Occurring During Mental Fatigue and Anoxemia. Trans. Kansas Acad. Science, 1940, 43, 343-44.

27

Fascist Attitudes of K. S. T. C. Students at Emporia

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Several recent studies dealing with reactions to labeled and unlabeled attitudes have brought certain aspects of attitudinal measurement more clearly into the open. Stagner (5) found that subjects may tend to reject items labeled "fascist," yet may accept fascist principles, provided they are not labeled as such. The same conclusion was reached by Katz and Cantril (3) in their studies of students' attitudes toward fascism and communism. Menefee (4), in his study of the effect of stereotyped words on political judgments, also found that the labeling of a statement with such a term as "fascism" would cause many students who had previously accepted it to now reject the same statement. Hartmann (2) also noted this same tendency.

These studies seem to indicate that reactions to labels which operate as stereotypes and reactions to principles which the labels subsume are not one and the same. While the importance of knowing a subject's reaction to a labeled statement cannot be denied, the true attitude can be judged most accurately by measuring reactions to unlabeled statements of opinion. However, the true attitude cannot be measured by merely removing the label, as the item itself may reveal the objective of the investigator. This difficulty was partially surmounted by Stagner (5) in the construction of his attitude scale, by applying the principle of disguised measurement. His attitude scale was so skillfully constructed that the attitudes being measured were not disclosed to the subject.

Stagner's scale, however, did not include the wider aspects of fascist ideology concerning such things as birth control, education, status of women, status of religion, etc. It dealt primarily with militarism, nationalism, contempt for lower classes, and opposition to labor unions. To remedy this defect and thus broaden the ideological concepts of fascism covered by Stagner's scale, Edwards (1) constructed a more comprehensive scale of unlabeled fascist attitudes. The statements used were selected from a variety of sources, including first of all Stagner's study, and secondly, information from the writings of Childs, Mann, and Kolnai. Edwards' revised scale is the one used in the present study of fascist attitudes of The Kansas State Teachers College of Emporia students.

The purpose of the present study was to measure the degree of acceptance of fascist principles by students of The Kansas State Teachers College of Emporia by means of an opinionnaire.

METHOD AND PROCEDURE

Mimeographed copies of Edwards' revised scale were administered to students in Introductory Psychology, Speech, and Educational Measurements classes at The Kansas State Teachers College, Emporia, during the summer session of 1942 and the regular school year of 1942-43. A class of army air privates was also given the scale. The instructors presented the scale to the

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students, requesting their cooperation in obtaining a cross-section of public opinion.

The subjects were asked to check their responses on a five-point scale, according to the directions given with the scale. The students returned the scale with their responses indicated after considering the items carefully at their leisure. The exact directions printed on the scale and the items therein were as follows:

This is an attempt to find out the extent to which people are agreed in their opinions about various problems which confront society today. What we are interested in finding out is: What is public opinion on these statements. *There are of course no "right" or "wrong" answers to these statements;* they are merely expressions of opinions. Will you please help us to get a cross section of public opinion by indicating *your opinion* on these statements?

To the left of each statement state your opinion by placing in the parenthesis that number which best represents your opinion.

If you *strongly disagree* with this statement....................write (1)
If you *disagree* with this statement....................write (2)
If you are *uncertain* about this statement....................write (3)
If you *agree* with this statement....................write (4)
If you *strongly agree* with this statement....................write (5)

Item

1. ( ) Children should be taught to be more obedient and to have more respect for authority by the public schools.
2. ( ) Whatever best serves the interests of government is generally right
3. ( ) The masses of people are not capable of determining what is and what is not good for them.
4. ( ) America has reached a higher state of civilization than any other country in the world and as a consequence has a culture which is superior to any other.
5. ( ) Over 10% of the population is incapable of democratic participation in government by reason of their lack of inherited abilities.
6. ( ) Generally speaking women are less intelligent and efficient than men.
7. ( ) The superior people in any culture are justified in dominating national affairs by force if necessary, because of the very fact that they are superior
8. ( ) Because many of the minor political parties merely confuse national issues, all political parties except the two major ones should be abolished.
9. ( ) The right to vote should be restricted to those individuals who have a specified amount of private property and therefore have a direct concern in the welfare of the country
10. ( ) A large per cent of the taxes which citizens pay is wasted in an effort to educate individuals who are not capable or worthy of being educated.
11. ( ) The right of the working classes to call a general strike should be abolished because it is a potential threat to democracy and is not in the general interest of society.
12 ( ) Patriotism and loyalty to one's country are more important than one's intellectual convictions and should have precedence over them.
13. ( ) A standing army of 2,000,000 men or over is necessary for our national defense at all times.
14. ( ) Government should attempt to persuade people to have more children and if necessary restrict birth control information for the benefit of our national defense.
15. ( ) In the national interest, private schools should be either abolished or restricted in their teachings so that the control of education is largely in the hands of the federal government.
16. ( ) Regardless of who our next president is, he must be a strong intelligent man and be given full power to run things in the interest of the government.

17. ( ) Certain religious sects whose beliefs do not permit them to salute the flag, should either be forced to conform or else be abolished.
18. ( ) There will always be superior and inferior races in the world and in the interest of all concerned it is best that the superior continue to dominate the inferior.
19. ( ) Our foreign markets are a vital necessity to our prosperity and must be protected at all costs.
20. ( ) Women have more ability and are more efficient at tasks around the home and as a result their rightful place is in the home and not in the business world.
21. ( ) Minor forms of military training such as drill, marching, and simple commands should be a part of the elementary school educational program.
22. ( ) Academic freedom is all right in principle, but instructors in high schools and colleges should not be allowed to express their convictions concerning their subject matter.

THANK YOU FOR YOUR COOPERATION

Now if you will please answer the following questions, it will aid us in making sure that we have a representative cross section of the public. *Remember you are not asked to sign your name. No one will know who filled out this blank.*

Age............................ Sex.................. Occupation..
Grade........................ Political Preference..
Church Preference............................ Parents' Political Preference............................
Estimated income for last year............................. Name of organization (society, club, fraternal) you feel yourself most closely identified with..................................

The responses for each subject were added to provide a summed score for each opinionnaire. An attempt was then made to translate these summed scores into a score which eliminated the uncertainty response of 3. Percentile rankings of the scores of the total population were then determined.

The total population was broken down into subgroups according to sex, class, and time of school attendance. These groups were compared as to differences in degree of acceptance of the principles of fascism.

An analysis was made of the items to determine which items were most agreed with and most disagreed with. A comparison was made between the upper and lower quartiles with respect to their responses to these items.

An attempt was made to analyze the character of the upper and lower quartile with respect to the questions asked at the end of the opinionnaire. An interpretation was made of the scores.

RESULTS: THEIR PRESENTATION AND INTERPRETATION

Table I presents percentile rankings for Edwards' Fascist Opinionnaire for 229 K S.T.C. students. The median is 54, $Q_1=46$, $Q_3=60$. The range of scores was 60; the lowest score was 22, the low possible, while the highest score was 82. Edwards obtained nearly the same range of scores from his subjects, the lowest score being 25, and the highest score being 85.

TABLE I. Percentile rankings for Edwards' Fascist scale for 229 K.S.T.C. students.

Percentile	Score	Percentile	Score
99	81	50	54
95	72	45	52
90	68	40	51
85	65	35	50
80	62	30	49
75	60	25	46
70	59	20	45
65	57	15	42
60	56	10	41
55	55	5	39
		1	29

The question arose as to the correctness of the score determination; that is, does the sum of the various item responses correctly indicate the individual attitude? The response of 3 (uncertainty) introduces a sizable weight to the score and yet it adds little to the positive or negative meaning of the sum score. It was thought that the uncertainty response could be subtracted and the remaining 1, 2, 4, and 5 responses averaged. A so-called corrected positive score was determined by means of the following formula:

$$\text{Postive score} = \frac{\text{Sum score}-(\text{no. of 3's} \times 3)}{\text{No. of certain responses}} \times 100$$

A "positive score" was a score denoting a positive attitude without uncertainty. The positive scores were then correlated with the sum scores to determine if there existed any significant difference in the rank order changes within the population. If a correlation of less than .90 were obtained then it was thought that a suggested rank order difference existed, that the uncertainty response of 3 materially affected the score. Such a correlation did not exist. Two samples of 25 cases each provided correlations of .97 and .99. The average number of uncertainty responses was 2.4. About 75 per cent of the opinionnaires listed three or fewer uncertainty responses.

An analysis was made of the class and group composition of the total population. There were represented summer school students, regular school students, men, women, freshmen, sophomores, juniors, and senior students of K.S.T.C., Emporia. Of the 500 army air force privates stationed at K.S.T.C. for pre-flight college training, a sampling of 47 was obtained. The various groups and classes were compared for the purpose of noting any differences in fascist attitude. Tables II and III show the results of this comparison.

TABLE II. The median, quartile deviation, and standard error of the median for the various groups

Group	N	Md	Qd	S E.Md
Regular School	143	52.72	6.53	.684
Summer School	86	55 33	7.36	.994
Men	41	53 75	7.67	1.50
Women	188	53 52	6.88	.621
Army Air Privates	47	57 11	4.84	.884
Freshmen	111	55.13	6.75	.803
Seniors	66	50 54	6.62	1.02
Total	229	53 57	7.01	.580

TABLE III Critical ratios between various groups.

Compared Groups	Critical Ratio
Regular School—Summer School	2.15
Men—Women	.14
Freshmen—Seniors	3.53
Air Privates—Freshmen	1.66
Air Privates—Seniors	4.87
Air Privates—Men	1.93
Air Privates—Regular School	3.93

From Table II it may be noted that the seniors are the most liberal in terms of the median score; next in order appear regular school students, then women, men, freshmen, summer school students, and last the air force privates. It so happened that the greater number of the privates in our sample came from the South.

An examination of the quartile deviations shows the summer school students as having the greatest dispersion of responses, while the army air privates have the greatest concentration.

Table III tabulates the critical ratios of difference between the various groups compared. There are no sex differences in opinion. The difference between the freshmen and seniors is quite reliable. The greater liberalism of seniors is established by many previous studies. The differences between the median score of opinion for the army air privates and the freshmen, and the army air privates and the men are unreliable, while the difference in median score opinion between the army air privates and seniors is most reliable. The comparison between the army air privates and the regular school students is also reliable.

A study was made of the median score value for each item of the opinionnaire. Table IV presents a comparison between Edwards' population and the Emporia population. In the first column the first number is the number

TABLE IV. Comparison of median response to each item.

Item		Edwards' Study		Present Study		
Edwards' Study	Present Study	High group (Fascists) N=16	Low group (Liberals) N=16	Fascists N=60	Liberals N=60	Total N=229
1	1	4.61	2.38	4.51	3.40	4.26 F
2	2	3.93	1.88	3.50	2.48	1.85 L
5	3	3.75	2.38			2.17
6	4	4.10	1 90	4.105	2.17	3.17 F
8	5	4 25	2.10	4.31	2.60	3.26 F
9	6	2.50	1.23	2.43	1 62	1 91 L
10	7	2 20	1 00			2.04
12	8	3.50	1 13			2 30
13	9	2.50	1.00	1 91	1 64	1 78 L
14	10	3.64	1 39			2.24
15	11	3.50	1.72			2.67
16	12	4.07	1.39			2.78
17	13	3.83	2.25	4.29	2.87	3 56 F
18	14	2.17	1.12	2 52	1 59	1.87 L
19	15	2.14	1.30			2.34
20	16	4.21	1.50			2.78
21	17	3.90	1.23			3.00
22	18	4.07	1.30	4 40	2.18	2 03 L
23	19	4.17	2.00	4.57	3.27	4.02 F
24	20	3.85	1.75			2.66
25	21	4.20	2.25			2.92
26	22	3 83	1.70			2.72

of the item in Edwards' published questionnaire (1) while the second number is our item number. The next two columns present the median score for each item for Edwards' high and low groups (N=16), the fascist- and liberal-minded, respectively. The size of Edwards' population for high and low score suggests that he used those subjects having a percentile ranking above 85 for for his high group and those below the fifteenth percentile for his low score group. Had the present study used a comparable group, the median scores would have shown a greater difference between the groups than that shown in Edwards' groups. The fourth and fifth columns present the median score for each of 10 items, the five most agreed and five most disagreed. These median scores are for our approximate upper (fascist) and lower (liberal) quartiles (N=60.) The last column presents the median score for each item for our entire population. Edwards' study did not provide median scores for each item for the total population. The five most liberally responded to items showing greatest disagreement with the item are identified by a letter "L"; while the five most anti-liberally responded to items (showing greatest agree-

ment with the item) are identified by a letter "F." In the order of their median score the items most disagreed with are:

(9) The right to vote should be restricted to those individuals who have a specified amount of private property and therefore have a direct concern in the welfare of the country (Md.=1.78)

(2) Whatever best serves the interest of government is generally right. (Md.=1 85)

(14) Government should attempt to persuade people to have more children and if necessary restrict birth control information for the benefit of our national defense. (Md.=1.87)

(6) Generally speaking, women are less intelligent and efficient than men. (Md.=1.91)

(18) There will always be superior and inferior races in the world and in the interest of all concerned it is best that the superior continue to dominate the inferior. (Md.=2.03)

The following are the five items most agreed with in the order of their median score:

(4) America has reached a higher state of civilization than any other country in the world and as a consequence has a culture which is superior to any other. (Md.=3.17)

(5) Over 10% of the population is incapable of democratic participation in government by reason of their lack of inherited abilities. (Md.=3.20)

(13) A standing army of 2,000,000 men or over is necessary for our national defense at all times (Md.=3.56)

(19) Our foreign markets are a vital necessity to our prosperity, and must be protected at all costs (Md.=4.02)

(1) Children should be taught to be more obedient and to have more respect for authority by the public schools. (Md.=4.26)

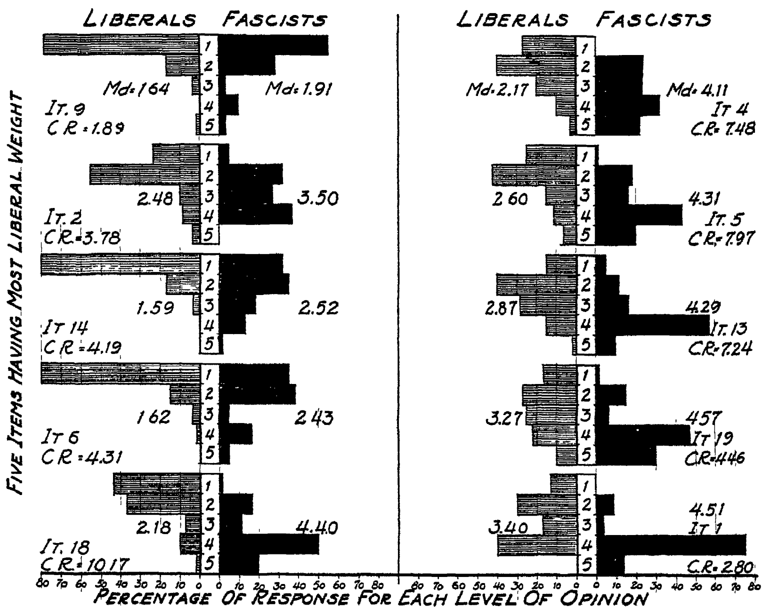

FIGURE 1. Distribution of responses to the five most agreed with and five most disagreed with items for the most fascist-minded 60 and the most liberal-minded 60 subjects.

To depict more effectively the difference in response and opinion of the liberal and fascist-minded students, bar diagrams were constructed as shown in Figure 1. Distributions were made of the responses to each of the 10 items shown above. The distributions were made from the responses of the most liberal 60 and the most fascist-minded 60 students, the approximate lower and upper quartile groups. The bar diagrams are paired. Note the shifts in the peaks for the two groups. On the left-hand side are shown the distributions for the five most-disagreed-with items; while on the right are shown the five most-agreed-with items. The numbers 1, 2, 3, 4, and 5 are the levels of opinion. The shaded bars are the distributions for the liberals, the solid bars for the fascists The median response score and the critical ratio for each distribution are indicated. The critical ratios of difference between the medians for each group for each item show reliability for eight of the items in discriminating the liberals from the fascists. Items 1 and 9 are not reliable. These two items show a reliable difference if the extreme groups are defined to the highest and lowest decile.

An attempt was made to analyze the make up of the group of subjects in the upper and lower quartiles. Nothing clear cut resulted from such a study. In both cases a Republican political preference predominated in the liberal and fascist groups, having nearly equal percentage representation. The Socialist Party was represented four strong in the liberal group with none in the fascist group. There were no independents in the fascist group. With respect to religious preference, the Methodists predominated in both groups. A few listed no preference, especially among the liberal group. A Jew received the most liberal score, a Catholic the most anti-liberal.

The political preference of the parents was distributed in similar fashion for both groups and agreed with the subjects' preference with few exceptions.

In an attempt to gain some idea of the source of the subjects' base line of evaluation and understanding of the various principles represented in the items, the question was asked concerning their identity with organizations or institutions. It was thought an organization or institution would impose a defining ideology upon its public and its membership would accept such ideology or mythology as a basis for evaluating political and social events and principles. There was no difference in the kind of organization and institution membership. The fascists listed more organizations than the liberals, but no difference in kind. The organizations listed were the usual type associated with campus and church life. An equal number in both groups listed no identifying membership or interest in an organization or institution.

Thus there could not be found in the information provided by the subjects any distinctions which could account for the acceptance or non-acceptance of the principles expressed in the items of the opinionnaire.

On the basis of an appraisal of the responses to the 22 items in the opinionnaire and the resulting score, the authors submit the following subjective interpretation of the sum score results:

Score

22– 40 Liberal-minded. Know and accept the principles of democracy Can recognize fascism.

41– 46 Tend to be liberal minded Are not clear as to the principles of democracy. Would accept them as operating principles if such principles were explicitly stated.

47- 60 Have no definite conception of the principles of democracy. Lack a social -political frame of reference from which to evaluate liberalism and fascism Can be induced to accept fascism.
61- 68 Tend to be fascist-minded. Would have no difficulty in accepting principles of fascism if identified and explicitly stated to them. Would accept fascist leadership.
69-110 Fascist-minded. Accept the principles of fascism.

The interpretations of the opinionnaire are subjective. One thing is certain, most students do not know what fascism is by principle. They know it only by label. The true marks of fascism are anti-liberalism, anti-labor, and anti-general welfare for the common people. These marks cannot be identified by the students in general. The greatest flaw in our present social-political setup is the lack of identifying principles. Political decisions are made in terms of personalities and labels. The average student grows in a social-political system void of defining principles; he has no background for making decisions and having well-defined opinions beyond mere feeling and symbol. The schools foster the system by providing no training in positive democracy. Thus the student cannot develop a system of social-political values, a frame of reference from which to evaluate the opinions stated in the present opinionnaire.

The interpretation of the scores that is presented is merely an interpretation and nothing more. It is harsh, but it seems justified when the individual responses to the items are analyzed.

The conclusions are inherent in the interpretations of the scores of the opinionnaire.

LITERATURE CITED

1. EDWARDS, A. L. Unlabeled Fascist Attitudes. J. of Abnormal and Soc. Psych. 1941, 36, 575-82.
2. HARTMANN, G. W. The Contradiction Between the Feeling-tone of Political Party Names and Public Response to Their Platforms. Journal Soc. Psych. 1936, 7, 336-57.
3. KATZ, D. & CANTRIL, H. An Analysis of Attitudes Toward Fascism and Communism. Journal of Abnormal and Soc. Psych. 1940, 35, 356-66.
4. MENEFEE, S. C. The Effect of Stereotyped Words on Political Judgments. Amer. Sociol. Rev. 1936, 1, 614-21.
5. STAGNER, R. Fascist Attitudes: an Exploratory Study. J. Soc Psych. 1936, 7, 309-19.

28

A Memory Study Employing a Factorial Experimental Design and the Analysis of Variance

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According to recent articles by Baxter (1), Dunlap (3), and Garrett and Zubin (9), psychologists have only begun to utilize the experimental designs and analytical techniques developed by Fisher and other investigators in agriculture. It is the purpose of this report to contribute another example of the application of these methods to a psychological problem.

The investigation (10) upon which this article is based follows a series of experimental studies of verbatim and summary retention by English and several associates. These studies have become best known through the four most recent experimental reports by English and Edwards (4, 5, 7, 8), and two theoretical articles in a controversial exchange with Buxton (2, 6). It was the purpose of the present investigation to critically examine the verbatim and summary studies and to design further experiments incorporating improvements of which these studies stood in need, but utilizing the basic experimental technique which they had developed.

It was the underlying purpose of English and his associates to arrive at a more carefully controlled experimental comparison of logical and rote memory. The extent to which their experimental method yields information which may be directly interpreted in terms of the basic problem has been questioned, but that is of no concern here. For the purpose of this article, it is feasible to begin by uncritically accepting their technique and not questioning its relevance to the basic problem.

The general procedure used in the present investigation is the same as that used by English and Edwards. The experimenter reads to the experimental subjects carefully selected subject matter over which a true-false test consisting of "verbatim" and "summary" items has been prepared. A verbatim, or V, item is as nearly as possible in the words of the text, covers a relatively small unit of thought, and is of such a nature that a correct answer is largely, theoretically might be purely, a function of rote memory. A summary, or S, item departs from the wording of the text, is based on the significance of larger portions of text, and is of such a nature that a correct answer indicates understanding of the point covered. The test, containing both types of items, is given immediately after presentation of the text. The same items are later used as a retest. This enables a comparison of the retention of verbatim and summary items—a comparison which was interpreted by English and his associates in terms of rote and logical memory.

In the earlier studies the verbatim-summary comparison was based on the averages of subjects' scores on the two parts of the test. In later studies English and Edwards gave up the group averages and based the comparison on a new type of item score—test-retest patterns of right and wrong. On any item which can be simply scored as "right" or "wrong", any one subject could be right on the first test and wrong on the retest (the RW pattern), wrong on

the first test and right on the retest (the WR pattern), right on both tests (the RR pattern), and wrong on both tests (the WW pattern). Each item was assigned four scores consisting of the number of subjects falling into each of these test-retest response patterns. English and Edwards called the RW pattern "forgetting" and the WR pattern "reminiscence." The RW and WR patterns were tested for independence from the V-S classification by the chi-square method.[1] Their findings indicated consistently that V was associated with RW and S with WR; in other words, that verbatim items tended to be forgotten and summary items reminisced.

The present investigation was planned to avoid certain difficulties encountered in the application of the chi-square test, particularly those having to do with the utilization of the RR and WW data. It was also deemed advisable to investigate the possibility that some of the differential retention found by English and Edwards was a function of the true-false classification of the test items. And since it was reasonable to set up the hypothesis that the verbatim-summary comparison is a function of knowledge of results on the first test, this variable was included in the experimental design.

By traditional methods all three of these variables—the V-S classification, the T-F classification, and the several methods of giving knowledge of results—would have been investigated one at a time in separate experiments with the other two variables held constant. But by employing a factorial experimental design, all three variables could be simultaneously investigated under conditions of normal variation in each variable. Such a design is not only more efficient, but yields information about possible inter-variable effects that single-variable experiments do not supply.

The V-S and T-F variables are simply the two dimensions of classification of the forty test items. Statistical equivalence of these two dimensions was provided by using twenty V items and twenty S items, with an equal division of T and F items in each such half of the test. Obviously, each of these variables has two levels[2] Four levels of the knowledge of results variable were provided by using four random samples of subjects (N=27), each subjected to a different knowledge of results treatment on the first test. Group I was given immediate knowledge of results as each item was answered. Group H was apprised of knowledge of results at the end of the experimental hour. Group W was given knowledge of results one week after taking the test. There was no provision for knowledge of results in Group N.

Table I is a simplified form of the three-dimensional, or 4x2x2, arrangement of the RW, or forgetting, data.[3] The sixteen combinations of the levels of the three variables are apparent in this arrangement, each entry being the RW data provided by the ten test items of a particular item classification under a certain method of providing knowledge of results For example, the upper-left entry, 52, is for combination IVT. It means that in the Method I group, there was a total of fifty-two instances of forgetting in the ten verbatim-true items.

[1]English and Edwards regarded the RR and WW patterns as irrelevant to a consideration of differential retention of V and S items and excluded these data from their statistical tests, the exclusion involving another controversial point with which this article need not become involved.

[2]Since the divisions of these variable are neither quantitative nor ordered, they are not levels in the typical sense, but more like the "varieties" in some agricultural experiments.

[3]This design is a slight modification of designs presented by Snedecor (12, Section 11.11), and by Rider (11, Section 64).

The single observations, the RW scores of each of the ten items in each combination of levels, are not included in Table I. It is upon these 160 obser-

TABLE I. RW data in 4x2x2 arrangement

		T	F	Total
Method I	V	52*	63	115
	S	33	56	89
	Total	85	119	204
Method H	V	48	65	113
	S	30	60	90
	Total	78	125	203
Method W	V	36	57	93
	S	26	50	76
	Total	62	107	169
Method N	V	41	53	94
	S	30	46	76
	Total	71	99	170
All Methods	V	177	238	415
	S	119	212	331
	Total	296	450	746

*Each entry represents total RW instances for the ten items of that combination of levels.

vations that the total variability—the variability of all the scores about the mean of all the scores—is based. The remainder of the analysis divides the total variability into the portions ascribable to each source of variability. These sources are the three variables, all possible combinations or "interactions" of these variables, and a remainder which may be regarded as a composite of uncontrolled sources and is usually termed "experimental error."

Table II presents the results of the analysis of variance of the RW scores.

TABLE II. Analysis of variance of RW scores

Source	Degrees of freedom	Sum of squares of deviations	Variance	F
T-F	1	148 225	148.225	15.71**
V-S	1	44.100	44.100	4.67*
Methods	3	28.925	9.642	1.02
T-F x V-S	1	6.400	6.400	.68
T-F x Methods	3	6.125	2.042	.22
V-S x Methods	3	1.350	.450	.05
T-F x V-S x Methods	3	2 050	.683	.07
Error	144	1358.600	9 435	
Total	159	1595.775		

**Significant at the 0.1% point.
*Significant at the 5% point.

"F" is the ratio of the variance of a given source to the variance of the experimental error. The significance of a source is determined by referring its F-ratio to a table derived from the known distribution of this function. The value of F for the T-F source falls beyond the 0.1% point; for the V-S source, at approximately the 4% point. The probability is less than .001 that as large a variance as is ascribed to T-F could be due to chance; it is approximately .04 that the variance ascribed to V-S could be due to chance. The other single source, Methods (knowledge of results), does not come up to the usually accepted minimum level of significance, the 5% point.

One is tempted to conclude (and some precedents are found in the literature) that more of the total variability in RW scores may be ascribed to the T-F variable than to the V-S variable. There is, however, no test for the

reliability of ratios between sources neither of which is experimental error. It is safer to say what was said above in a different way, that we are more certain that the portion of total variability ascribed to T-F is not due to chance than we are about the portion ascribed to V-S.

Even though they are all insignificant, special attention should be given to the four interactions since they are an important feature of the factorial experimental design. Although the factorial design is a more efficient method of getting information regarding the single sources, such information can be obtained by a multiplicity of single-variable experiments. But the information regarding interactions between variables is not available through the more traditional procedures. Here is an example of the importance of such information. Since RW scores were shown to be dependent upon both the T-F and V-S variables, the question naturally arises whether the relationship between the T-F variable and RW scores is independent of the V-S variable, and whether the relationship between V-S and RW is independent of T-F. Single-variable methods provide no satisfactory answer to this type of question.

In the investigation proper, the above analysis was repeated for the WR, or reminiscence, data, and the correct disposition of the other two patterns of data was investigated. However, these matters do not come within the scope of this article, which is only incidentally concerned with the investigation as a whole.

The emphasis in this report upon experimental design and method of analysis is not with pedagogical intent. But at this stage of the psychologist's utilization of these methods, there is a need for reports of actual, not mere illustrative, studies in which the investigator describes his attempted applications in some detail and thinks out loud in his interpretations of the analyses. Such contributions from investigators of average statistical ability should hasten a proper utilization of these methods by facilitating the correction of errors of application and interpretation—errors which are inevitable in the process of adapting the tools of another field of science.

LITERATURE CITED

1. Baxter, Brent Problems in the planning of psychological experiments. *Amer. J. Psychol.,* 1941, 54, 270-280.
2. Buxton, Claude E. 'Reminiscence' in the studies of Professor English and his associates. *Psychol. Rev.,* 1942, 49, 494-504.
3. Dunlap, J. W. Applications of analysis of variance to educational problems *J. educ.* Res., 1940, 33, 434-442.
4. Edwards, A. L., and English, H. B. The effect of the immediate test on verbatim and summary retention. *Amer. J. Psychol.,* 1939, 52, 372-375.
5. ———. Reminiscence in relation to differential difficulty. *J. exp. Psychol.,* 1939, 25, 100-108.
6. English, H. B. Reminiscence—reply to Dr. Buxton's critique. *Psychol. Rev.,* 1942, 49, 505-512.
7. English, H. B, and Edwards, A. L. Studies in substance learning and retention: XI. The effect of maturity level on verbatim and summary retention. *J. gen. Psychol.,* 1939, 21, 271-276.
8. ———. Reminiscence, substance learning, and initial difficulty—a methodological study. *Psychol. Rev.,* 1939, 46, 253-263.
9. Garrett, Henry E., and Zubin, Joseph. The analysis of variance in psychological research. *Psychol. Bull.,* 1943, 40, 233-267.

10. MOGGIE, MAURICE C. A factorial experimental investigation of test-retest trends in verbatim and summary test items. Unpublished Doctor's Dissertation, Ohio State University, 1942.
11. RIDER, PAUL R. An introduction to modern statistical methods. New York: Wiley, 1939.
12. SNEDECOR, GEORGE W. Statistical methods, revised edition, Ames, Iowa: Collegiate Press, 1938.

29

The Effect of Temperature Changes Upon the Behavior of the White Rat

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Today, it is recognized that a wide range of environmental forces must be considered as co-operative factors in the development of the organism. Changes in temperature have been found to be an important aspect of these influences. The physical and behavioral characteristics of many organisms change as the temperature under which they live varies. The purpose of the present study is to determine the influence of changing temperature upon the maze behavior of the white rat.

Three well insulated rooms were equipped to house about sixty rats each. A refrigeration unit maintained a temperature of 55-58° F in the cold room. The temperature of the control room was kept the same as the rest of the building. The usual range was a few degrees above and below a mean of 75°. The hot room was equipped with a small electric heater which maintained a temperature of 88-90° F. Adequate ventilation was provided for all three rooms.

The litters from thirty female albino rats were used as the experimental animals. At twenty-eight days of age, rats in these litters were weaned, marked, and divided so that one-third of each litter was placed in each of the three rooms. Sex and average weight at the time of division were equated. Weekly weight records were kept throughout the course of the experiment. During maze running, daily weight records for each rat were taken

Approximately forty-five rats in each room were required to learn a simple four-alley maze. Records of trials, errors, and time were kept, and the criterion of learning set at three successive errorless runs. After learning the maze, the rats in each room were divided into three sub-groups, equated on the basis of sex and average trials required to learn the maze, and were then placed in the various rooms. For example, in the cold room one sub-group of 15 was left in that room. A second sub-group, equal in average trials required for mastery of the maze, was placed in the control room. The third sub-group was moved to the hot room. The same procedure was carried out with the rats learning the maze in the control and hot rooms.

Forty days after original learning, the rats in the three rooms relearned the maze. Again the criterion of learning was three consecutive errorless runs, and the same records of time, trials, and errors were kept. After relearning, all rats in the three rooms were tested in a modified obstruction box. The grid of this box was connected to a small induction coil, and the voltage checked frequently to insure constant current value. Fifty rats in each room were tested, and it is believed that with such large groups representative results can be obtained without elaborate precautions to insure exactly the same shock to each rat. Daily weight records during grid tests were also taken. At the end of the experiment the rats were killed and the body lengths and tail lengths measured.

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Weight records for rats living continuously in the three rooms show that the animals in the cold room grew most rapidly and reached an average weight of approximately 230 grams at eighteen weeks of age. In the hot room, the rate of growth was slower, and the average weight at eighteen weeks was only 200 grams

The different temperatures tend to produce changes in body structure. Rats living continuously in the cold room develop shorter tails and more rounded, relatively heavier, bodies. Modification of body structure characterized by longer tails and relatively longer, more slender, bodies was found in the rats living continuously in the hot room.

Maze performance, measured in terms of trials, errors, and time, shows that the rats living and learning the maze in the cold room have a great advantage over a similar group living in the hot room. The control room group stands about midway between the hot and cold room groups in maze performance. In the cold room, 19.8 trials, 141 errors, and 4443 seconds were required for mastery of the maze. The corresponding values in the control room were 25.9 trials, 143 errors, and 5180 seconds. Hot room rats required 36 6 trials, 245 errors, and 8270 seconds for learning the maze.

When the rats were tested for retention about forty days later, it was found that every time a group was moved to a room of higher temperature the number of trials required for mastery of the maze increased. Comparison, of course, was made with the trials required for relearning of an equal group in the original room In the cold room, for example, the group left there required 7.1 trials, 17.4 errors, and 559 seconds to learn the maze. A second equal group, placed in the control room for forty days needed 9.8 trials, 31.8 errors, and 1090 seconds for relearning. The third group relearning in the hot room thirty-six days after completing the original tests required 13.0 trials, 50.6 errors, and 1336 seconds. The same trend was observed in the control and hot rooms. As the groups were moved to rooms of lower temperature, learning scores decreased, and increased when groups were placed in rooms of higher temperature. Variability of performance follows a trend similar to that found in original learning. The critical ratios of the differences between means indicate that the differences are reliable.

The groups of rats originating in different rooms but relearning the maze in the same room show almost the same level of ability. Critical ratios of the differences between means are in general quite small. There is some tendency for rats originally from the cold room to require the fewest trials on relearning when compared with the groups from the hot or control rooms relearning in any one room. Rats originally from the hot room seem to be in second place in relearning in the three rooms most frequently, and those learning the maze in the control room show the poorest performance of the three groups relearning in the control and hot rooms. Calculation of the percentage saving found in relearning shows the same general trend.

Analysis of the progress of learning by means of modified Vincent curves indicates that in original learning the general order of elimination of errors is about the same in all three rooms. The hot room groups start with a greater number of errors for the first trials, and fail to progress as rapidly during the last portion of the learning. In the relearning trials, the lack of progress in eliminating errors during the latter portions of the maze by rats relearning in

the hot room, is even more pronounced. At one time during relearning, the rats in all three rooms displayed about the same number of average errors per tenth of the learning period.

In the obstruction box tests it was found that rats tested in the cold room crossed the grid an average of 29.5 times during the 20 minute test period. In the control room, there were on the average, 14.8 crossings per rat, and in the hot room, only 8.1 average crossings during the test period. The general pattern of activity, when approaches, contacts, and crossings are considered, is about the same in all three rooms. The behavior of the sub-groups within each room shows some similarity in that the hot room group stands first in the number of crossings in all three rooms, first in the number of contacts in two of the rooms, and first in total number of approaches in the cold room. There is, however, little correlation between grid crossings and trials required for relearning the maze. Coefficients of correlation calculated on a room-by-room basis, as well as when performance of sub-groups in each room was compared, indicate little relationship between these two measures. It was also found that rats dropped from the learning tests for refusal to run the maze, made about as many crossings when tested on the grid as did those which successfully learned the maze both times in the same room.

A comparison of performances with records of weight losses during learning, relearning, and grid tests for the rats in each room was made. Although the evidence is not conclusive, the results suggest that differences in weight losses in the three rooms may influence the performance of the rats in each room. The greater weight loss by the cold room rats during the same period of starvation used in all rooms may act to produce a greater degree of motivation in these rats. A number of other factors, however, are also probably responsible for the differences in performance found in the three rooms.

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The Development of Concept Formation in Children

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Aside from the work of Piaget (2) there has been little attempt to study the development of concept formation in children. The need for a developmental study which would provide a tentative set of norms for the evaluation of clinical material prompted the undertaking of the present research. We used two tests of concept formation, the *Color-Form Test* and the *Sorting Test* first described by Weigl (4), and later by Goldstein and Sheerer (1). Inasmuch as these tests were originally designed for work with brain-injured patients, we in our clinical work with various neurotics, psychotics, and cases of behavior disorders, found that many new types of reaction to these tests became apparent. The only previous developmental study of these tests is that of Jane Thompson (3), which, however, pursued less specific aims.

The subjects employed in the present study were two hundred thirty-four white children ranging in age from four to fourteen years, inclusive. The four-year-olds were drawn from a nursery school, the remainder from the Topeka public school system.[1] Only children who were normally placed in their grades were tested.

The Color Form Test consists of twelve pieces of cardboard of four different colors and three shapes. The subject first is asked to "put together all those that belong together." After he has made his first sorting either on the basis of form or of color, he is asked to "put them together in another way, a different way." Success is marked by the ability to shift from one category to the other; failure by repetition of the first category, or by the construction of patterns or mixed groupings. Scoring accordingly distinguishes between subjects who are able to make two, one, or no groupings.

The Sorting Test consists of thirty-three objects which may be grouped according to use, color, form, material, or existence of pairs. In the first part of the test, the subject is handed seven objects, one at a time, and told to put with each "all that belong with it." After he has completed his grouping, he is asked to tell why they belong together. The second part of the test consists of the presentation by the examiner of twelve groupings which the subject is asked to define. In scoring this test, sorting behavior was scored plus, plus-minus, minus-plus, minus, according to the accuracy of sorting, and loose or narrow according to whether the subject included more or fewer objects in his sorting than the concept in question required. Loose groupings are characteristic of schizophrenics who tend, for example, to put with a ball any object that contains a rounded portion, while narrow groupings are found in depressives who have difficulty in finding any object to go with the sample object presented. In addition, the subject's definitions were scored according to the level of conceptualization manifested, where concretistic, funtional, or conceptual. Aside from the concretistic, a number of other types of inadequate

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[1]The authors wish to express their appreciation to Mr. Strong Hinman, Assistant Director of the Board of Education, and to the principals, teachers and students of the Gage, Lincoln, Branner, Potwin, and Roosevelt schools for their generous cooperation in this project.

response were distinguished. All of these are grouped together in Tables II and III as inadequate responses. Finally, a subject sometimes was unable to give any explanation of the groupings.

TABLE I. Results of Color-Form Test.

Age	No of Subjects	Percentage of Successes 2	1	0	Percentage of Color and Form Groupings Color	Form
4 years	10		80	20	10%	70%
5 years	25	36	44	20	72%	8%
6 years	24	17	75	8	42%	54%
7 years	27	59	37	4	-------	-------
8 years	19	58	42		32%	66%
9 years	24	75	25		33%	67%
10 years	22	72	28		36%	64%
11 years	27	67	29	4	22%	74%
12 years	25	80	20		36%	64%
13 years	23	83	17		26%	74%
14 years	13	69	31		31%	69%

Chi Square of Differences Between Age Groups

Group	X^2	Chances that Difference is not Reliable
4–6 years	2.49	30%
6–7 years	9.6	1% (less than)
6–8 years	9.0	2% (less than)
8–9 years	1.39	50%

The results obtained with the *Color-Form Test* are summarized in Table I. It was found that children below five years do not shift from a grouping principle which they have once conceived. This behavior may be due to perceptual dominance as well as to inability to shift Around seven to eight years the ability to form two groupings becomes predominant, and above eight years even the Piaget criterion of success is met, inasmuch as seventy-five per cent or more of the children are able to form both color and form groupings, thus shifting from one principle to another. The shift occurring around seven to eight years was found to be statistically reliable. (See Table I). There is a steady increase in percentage of successes with increase in age; however, an exception to this is the five-year group which, for reasons which space does not permit us to describe, was found not to be comparable with the rest of our population. The data also show that the population which we tested is inclined to sort more in terms of form than of color.

Table II comprises the means of all the scores obtained on the *Sorting Test.* This table indicates that there is a general tendency, on both parts of the test, for both the number of correct responses and of conceptual definitions to increase with age. Comparison of the scores for grouping and verbalization on the first part of the test reveals that grouping ability develops faster than

TABLE II. Sorting-test Summarized Means*

	Part I										Part II				
	Grouping					Verbalization									
Age	+	L	(L)	N	(N)	+	CD	FD	In	M	+	CD	FD	In	M
4	2.0	1.1	.3	3.2	.9	1.0	.1	.8	2.6	3.7	1.4	.7	.6	3.3	7.5
5	5.1	.7	1.4	1.4	2.8	3.8	2.5	.8	2.2	1.3	3.6	2.9	.7	7.3	1.1
6	4.4	.2	.2	4.0	2.1	2.9	1 4	1.7	1.5	2 4	4.1	2 5	1.6	6.1	1.8
7	4 7	.6	.5	2.7	1.1	4.4	2 2	1.9	2.1	8	5.8	3.7	1 8	5.6	.9
8	5.1	.1	.3	2.7	2.0	4.9	2.0	2.6	1.1	1.3	6.4	4 3	1.7	5.1	1.1
9	5.7	.4	.6	2.0	2.1	5.5	2.8	2.4	.9	.8	6.6	4.3	2.0	4.3	1.4
10	5.7	.5	1 0	1.4	1.9	5.6	3.1	2.1	1.1	.7	7.0	4.8	1.7	4.4	1.0
11	5.7	.1	.9	1.6	1.2	5.4	3 1	1.7	1.3	.6	8.0	6.5	1.2	2 8	1.4
12	5.8	.3	1.2	1.4	1.9	5.5	2.9	2.2	1.5	.4	8.0	6.4	1.6	2.6	1.5
13	5.9	.3	1.5	1.1	2.0	5.8	3 2	1.9	1.1	.7	8.3	6.5	1.6	2.3	1.7
14	5 5	.5	1.5	2 2	.9	5.2	3.2	1.4	1.6	.8	10.3	8.6	1 5	.7	1.2

* +—correct   N—narrow   FD—functional definition
L—loose   (N)—slightly narrow   In—inadequate responses
(L)—slightly loose   CD—conceptual definition   M—missed, i.e., failed to respond

does the ability to give verbal explanations for one's groups, thus confirming Piaget's findings (2).

Both extremely narrow and extremely loose groupings are found in very young children, thus attesting the amorphous nature of concepts at this early age. Mildly loose groupings (groupings which included one or two objects not strictly within the bounds of the concept), on the other hand, show a steep rise during adolescence.

The results appear to indicate three levels of conceptual development; namely, concretistic, functional, and conceptual. The first is characteristic of the youngest children. The second stage begins when the children succeed in making their first relevant classifications, which they do mainly in terms of what use the objects are to them. This functional level of concept formation reaches its peak around eight to nine years, after which it is gradually replaced by more mature, conceptual classifications. This last stage appears to reach relative maturity around eleven years of age.

TABLE III. Sorting-test Percentages

		Part I					Part II				
	Grouping	Verbalization									
Age	+	+	CD	FD	In	M	+	CD	FD	In	M
4	29	14	1	11	37	53	12	6	5	28	63
5	73	54	36	11	31	19	30	24	6	61	9
6	63	41	20	24	21	34	34	21	13	51	15
7	67	63	31	27	30	11	48	31	15	47	8
8	73	70	29	37	16	19	53	36	14	43	9
9	81	79	40	34	13	11	56	36	17	36	12
10	81	80	44	30	16	10	58	40	14	37	8
11	81	77	44	24	19	9	67	54	10	23	12
12	83	79	41	31	21	6	67	53	13	22	13
13	84	83	46	27	16	10	69	54	13	23	14
14	79	74	46	20	23	11	86	72	13	6	10

Comparison of the first and second parts of the test as seen in Table III reveals that the percentage of correct responses is much higher on the first part of the test at all age levels, but that conceptual definitions are more readily given in preference to functional definitions on the second part of the test. The fact that children succeed more easily on the first part of the test is interesting in view of the finding that adult psychotics frequently do well on the second (apparently more difficult) part of the test, and quite poorly on the first part. This result appears to indicate that the ability to comprehend the concepts of others often survives, while the extent of the impairment of functioning becomes readily apparent when the patient has to form his own concepts.

SUMMARY

I The importance of tests of concept formation in clinical psychological work was discussed, and a study was presented, the principal aim of which was to provide a tentative set of developmental norms against which clinical material might be evaluated.

II. The tests used were the *Weigl Color-Form* and *Sorting Tests.* The results showed a rather steady increase in ability to group together objects which belong together and in ability to give abstract, conceptual explanations of the groupings. Various types of inadequate responses were noted and a steady decrease in the number of such responses was also observed. Thus a rough age-scale is provided for the evaluation of the degree and type of failure in clinical cases.

III. A clinical and psychological study of psychiatric cases, for which this report forms a preliminary investigation, is now in progress.

BIBLIOGRAPHY

1. Goldstein, K., and Scheerer, M. Abstract and Concrete Behavior: An Experimental Study with Special Tests. *Psychological Monograph*, Vol. 53, No. 2, 1941, Pp. 151.
2. Piaget, Jean. Judgment and Reasoning in the Child, Harcourt Brace & Co., New York, 1928, Pp. 260.
3. Thompson, J. The Ability of Children of Different Grade Levels to Verbalize on Sorting Tests. *Journal of Psychology*, 1941, 11, Pp. 119-126.
4. Weigl, Egon. On the Psychology of So-Called Processes of Abstraction. *Journal of Abnormal and Social Psychology*, Vol. 36, No. 1, January, 1941.

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Gonadotropic Effects of Capon and Normal Male Blood Serum

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It is a well known fact that the gonadotropic homornes of the pituitary gland stimulate development of the gonads and in turn the production of sex hormones from the gonads. It is frequently stated but less well confirmed that sex hormones, both male and female, in turn reduce pituitary activity. A functional balance, therefore, is believed to exist between pituitary and sex hormones. If some factor alters this balance, the alternate gland or glands is said to be affected. If sex hormones depress pituitary activity, the question may be asked, "Upon removal of the sex glands, does the pituitary become more active than in normal animals with gonads intact?"

With these facts in mind, experiments were conducted in an attempt to determine if blood serum from normal animals has gonad stimulating qualities different from or equal to blood serum from castrate animals.

These experiments consisted of giving by means of intramuscular injection, blood serum from normal male chickens to a group of 10 young chickens and blood serum from capons to a similar group of 10 chickens. The chickens were 19 days old at the beginning of the experiment and each received one-half cubic centimeter of serum on alternate days until a total of 4 cc. was given. A third group of 10 male birds was selected at the beginning of the experiment to serve as normal controls.

On the day following the last injection the birds were weighed and killed. The testes were removed, weighed on an analytical balance, and fixed in Bouin's fluid to be sectioned later. Since the two testes of each pair are normally unequal in size, the left one from each bird was selected for histological study. The tissues were sectioned and stained according to routine technique with alum haematoxylin. A histological study was made in which the tubules of the testis were measured with an ocular micrometer. The diameters of seventy-five tubules and their lumena were measured from each testis. An average of these was taken as the representative diameter of the tubule and lumen for that bird.

There was little variation in the size of the tubules within a single testis and even among the separate groups. The average diameter of those receiving normal male serum was 50.7 micra; those receiving capon serum, 49.7 micra; and from the normal birds that received no injections, 50.2 micra. There was likewise no significant difference among the measurements of the diameter of the lumen of the tubules.

When the birds were killed the body weights of the three groups were practically identical, but there was a striking difference in weight of the testes. The average weight of testes of birds receiving normal male serum was 57 milligrams; those receiving no injections average 58.7 milligrams; and those receiving capon serum averaged 80.4 milligrams.

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This significant difference in weight of testes of injected birds indicates that the pituitary glands of capons are more active in producing gonad stimulating substance than in normal intact birds. It further suggests that sex hormones in normal animals suppress pituitary activity.

The Mollusca of Meade and Clark Counties, Kansas

ALICE E. LEONARD, Lawrence, Kansas

INTRODUCTION

During the past several summers, I and my husband have had the pleasure of working from the field camp of Dr. C. W. Hibbard, Curator of the University of Kansas Museum of Vertebrate Paleontology. During this period the camp was located at or near Meade County State Park. While the efforts of the party were directed mainly toward a study of the Pliocene and Pleistocene faunas of the region, there were opportunities for studying the recent molluscan fauna, and with the kindly and able assistance of other members of the party, a rather thorough collection of the mollusks of Meade County was made, together with some collections from Clark County as well.

I take this opportunity of expressing my thanks to Dr. Hibbard for the facilities so generously placed at my disposal; to Dr. W. H. Horr, Department of Botany, the University of Kansas, who identified the plants listed below; to Mr. and Mrs. Clarence Rexroad, upon whose ranch the camp was located for several seasons, for their splendid hospitality; to Mr. Leonard Sutherland, Superintendent of the Meade County State Game Farm, for allowing us the privileges of the park; and to many others of the community whose friendly cooperation made possible this work in Meade County.

At first glance, the southwestern region of Kansas would not seem to offer many likely habitats for mollusks. The area lies in the eastern border of the High Plains Region, characterized by short grasses, sagebrush, yucca and prickly pear flats, and scant timber and shrubbery. There is very little permanent water. Practically speaking, the only permanent streams, excepting of course, the Cimarron River, are Crooked Creek, which pursues an anomalous course along a fault line across eastern Meade County transverse to the general drainage pattern; and Bluff Creek in northern Clark County. There are numerous small streams which drain toward the Cimarron River, but none support any considerable molluscan fauna, due to their ephemeral character. The climate is semi-arid, with a normal rainfall of about 20 inches, but in the last twelve years the annual precipitation has been consistently below normal; during several seasons the annual rainfall has been scarcely more than ten inches, (Fig. 1.) During these dry years the vegetation on the plains almost completely disappeared, the soil drifted before the wind, and little remained except the sagebrush, yucca, and prickly pear The scant timber of the region consists mainly of cottonwood trees along the water courses, with lesser numbers of elm, hackberry and black locust. Thickets of wild plum are found along the dry stream courses, especially where the soil is sandy. There is nowhere any considerable amount of leafmold or other organic debris suitable for snails, due in part to the custom of burning the pastures in the spring.

The Meade Artesian Basin is a sort of mesophytic oasis in this semi-arid region. Artesian springs, some of which flow several hundred gallons of water

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per minute, provide water for permanent ponds and streams. Where these springs seep toward the surface, meadows and marshes develop. The character of the vegetation reflects this change of environment; sedges, aquatic grasses, reeds, and algae are common, providing suitable conditions for many molluscan species. Meade County State Park is located in a series of ravines containing several springs of both the free-flowing and seeping type. This fact, together with the lack of grazing by cattle, results in a series of almost ideal habitat conditions for mollusks. This favorable habitat is attested by the fact that 23 of the 26 species reported from the two counties may be found within the limits of the park, which contains only a few hundred acres.

A second feature of the terrain which tends to favor certain species of mollusks is the presence of sink-hole ponds. These are more or less ephemeral lakes or ponds which are composed of surface waters that have collected in depressions apparently produced by the settling of the surface following solution and collapse of the deeper geological formations. These depressions range in diameter from a mile or so to several times that size; the ponds range from small pools to lakes covering a hundred acres or more. Such lakes may endure for several seasons, supporting a considerable growth of aquatic vegetation, and great numbers of certain mollusks, such as *Helisoma trivolvis,* with smaller numbers of *Physa hawni* and *Lymnaea bulimoides techella* or *L. b. cockerelli.* During dry periods these shallow bodies of water evaporate and disappear, and not infrequently the land is placed under cultivation for several successive seasons.

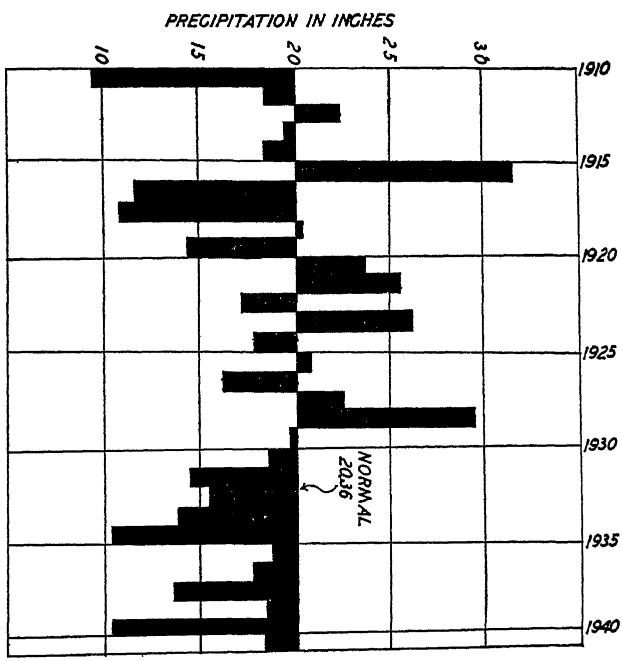

FIGURE 1. Precipitation at Plains, Meade County. Annual departure from normal precipitation at Plains.

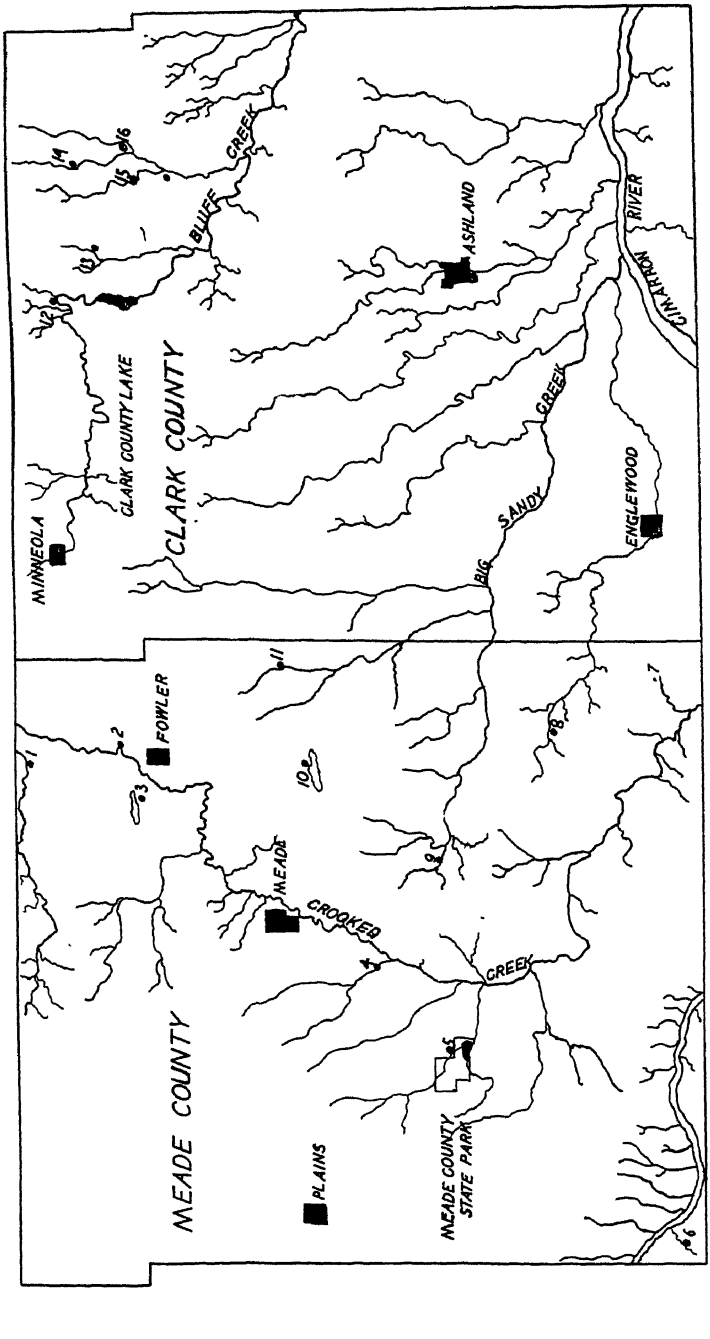

FIGURE 2. Map of Meade and Clark Counties showing main drainage pattern and principal collecting stations.

The molluscan fauna of Kansas has not been extensively investigated. Hanna (1909) reported upon the gastropods of Douglas County in eastern Kansas, Scammon (1906) studied the Unionidae of the state, and Franzen and Leonard (1942) published a preliminary report of the gastropod fauna of Kingman County, central Kansas. So far as known to me, no study of the recent molluscan life of the southwestern region of Kansas has been published, nor has there been a previous report upon the molluscan fauna of any area in the High Plains Region.

The characteristics of the flora of the Meade Artesian Basin are indicated by the list of plants given below, which were taken from the meadows and marshes at the Meade County State Park. In this list the name of the family is followed by the scientific name, common name, and the habitat when known.

Aneura penguis. Mouse runways.
Riccia fluitans. Brooder ponds.

Family Marsileaceae
Marsilea vestita Hooker & Greville. "Floating fern"; Lake Larrabee.

Family Equisetaceae
Equisetum kansanum Schaffner. "Horsetail"; creek banks.

Family Najadaceae
Potamogeton sp. "Pondweed"; ponds.

Family Alismaceae
Sagittaria esculanto Howell. "Arrowhead"; marshes.
Lophotocarpus calycinus (Englemann) Smith (?). "Arrowhead"; marshes.
Echinodorus cordifolius (Linnaeus) Grisebach. "Arrowhead"; marshes.

Family Graminae
Andropogon saccharoides Swartz. "Beard grass"; meadows.
Sorghastrum nutans (Linnaeus) Nash.
Echinocloa crusgalli var. *mitis* (Pursh). "Barnyard grass"; creek and drained lake bottom.
Setaria geniculata (Lamarck) Beauvois Persoon. "Foxtail"; pond.
Cenchrus panciflorus Bentham "Sandburr"; roadside.
Spartina pectinata Base. "Marsh grass"; grass common in wet situations.
Bouteloua curtipendula (Michaux) Torrey. "Mesquite grass".
Eragrostis cilianensis (Allioni) Link. Roadside ditch.
Hordeum jubatum Linnaeus. "Squirrel-tail grass"; marsh north of No. 1 pond.

Family Cyperaceae
Cyperus schweinitzii Torrey. Along streams in park.
Cyperus speciosus Vahl "Sedge"; along ponds.
Cyperus strigosus Linnaeus. "Sedge"; meadow.
Cyperus lancastriensis Porter (?) "Sedge"; near artesian creek.
Cyperus houghtoni Torrey (?). "Sedge"; meadow.
Cyperus bushii Britton (?). "Sedge".
Eleocharis rostellata Torrey. "Sedge"; marshes.
Eleocharis palustris (Linnaeus) Roemer & Schultes. "Sedge"; marshes & ponds.
Fimbristylis puberula (Linneaus) (Michaux) Britton. "Sedge".
Scirpus paludosus (Nelson) (Fernald) (?) "Sedge"; marshes, park.
Scirpus americanus Persoon. "Sedge"; common near fish pond.

Scirpus validus Vahl. "Sedge"; marsh.
Family Lemnaceae
Spirodela sp. "Duckweed"; ponds.
Family Commelinaceae
Commelina crispa Wooton. "Day flower"; creek bank.
Family Juncaceae
Juncus dudleyi Wieg. "Rush".
Juncus torreyi Coville. "Rush".
Family Saliaceae
Salix sp. "Willow"; creeks.
Family Polygonaceae
Rumex persicariodies Linnaeus. On drained lakebed.
Persicaria pennsylvaincum (Linnaeus). "Small smartweed".
Persicaria omissa Greene.
Family Amaranthaceae
Amaranthus graecizaus Linnaeus. "Tumbleweed"; meadow in park.
Family Ranunculaceae
Myosurus minimum Linnaeus. "Mousetail"; pond in sink.
Family Cruciferae
Nasturnium officianale (Linnaeus). "Water cress"; creek & springs.
Family Capparidaceae
Peritoma serrulatum (Pursh). "Stinking clover"; in low places especially along crooked creek.
Family Leguminosae
Desmanthus illinoensis (Michaux) MacMillan Miller. "Mimosa"; park.
Family Leguminosae
Amorpha fragrans Sweet. Streams in park.
Glycyrrhiza lepidota (Nuttall) Pursh. "Licorice"; marshes.
Family Euphorbiaceae
Lepadena marginata (Pursh) Niewll. "Snow on the mountain"; thickets, common in spots.
Croton texensis (Klotzsch) Mueller Arg. Grassland.
Family Anacardiaseae
Rhus var. *trilobata* (Nuttall) Gray. "Aromatic sumach"; park.
Family Lythraceae
Ammannia coccinea Rottboell. Wet marshes on drained lakebed.
Family Haloragidaceae
Myriophyllum sp.
Family Primulaceae
Samolus floribundus Humboldt. "Water pimpernell"; sedge association near upper pond.
Family Gentianaceae
Eustoma russellianum (Linnaeus) Grisebach. "Prairie lily"; normally in wet places on saline soil. Along Cimarron River flood plains.
Family Apocynaceae
Apocynum medium Greene. Marshy meadow.
Family Asclepiadaceae
Asclepias incarnata Linnaeus. "Swamp milkweek".
Acerates auriculata Englemann (?). Meadows.

Family Verbenaceae
Lippia lanceolata Michaux. Along streams in park.
Verbena angustifolia x *hasta.*
Verbena bracteosa Michaux. Near farm buildings.
Verbena hastata x stricta. Park.
Family Labiatae
Scutellaria lateriflora Linnaeus. "Skullcap"; ponds & creek.
(*Salvia pitcheri* Torrey). Roadsides.
Salvia lanceaefolia Poiret. "Sage"; park.
Lycopus americanus Muhlenberg. Creek banks.
Family Scrophulariaceae
Mimulus geyeri Torrey. "Monkey flower"; upper pond.
Agalinis setacea (?) Park.
Family Rubiaceae
Galium aparaine Linnaeus. "Bedstraw"; ditchbanks & thickets.
Family Lobeliaceae
Lobelia cardinalis (splendens) (Linnaeus). "Cardinal flower"; along creek in wet places.
Family Compositae
Euthamia graminifolia (Linnaeus) Salisbury. "Goldenrod"; thickets.
Erigeron canadensis Linnaeus. "Fleabane" or "horseweed"; streams.
Ambrosia psilostachya DeGandolle. "Ragweed"; meadows.
Ambrosia trifida Linnaeus. "Great ragweed"; mesophytic conditions.
Artemisia filifolia Torrey. "Sagebrush".

PELECYPODA

Anodonta grandis Say, Plate 2, Fig. No. 22, 23

This large mussel, commonly called the "floater", is characterized by its oval outline, thin shell, dark green or brown color, and lack of teeth along the hinge line.

Occurrence: Throughout the upper reaches of Crooked Creek, *Anodonta grandis* occurs in "beds" including many individuals, but in the stream below the town of Meade, where the bottom becomes sandy, this mussel is absent. The dry beaches left when Lake Larrabee was drained were covered with the shells of *A. grandis.*

Uniomerus tetralasmus (Say), Plate 2, Fig. No. 26, 27.

This mussel, which was found in the deep pools of the upper portion of Crooked Creek, along with *Anodonta grandis* is smaller than the latter, more angular in outline, and of a rich brown color embellished with bands of mahogany. Unlike *A. grandis,* there are both pseudocardinal and lateral teeth along the hinge line.

Occurrence: Not found except in the deep pools of upper Crooked Creek.

Sphaerium solidulum (Prime) ?, Plate 2, Fig. No. 24, 25

This small pelecypod is about one half inch in diameter, and subcircular in outline. The surface is conspicuously marked with concentric ridges. In *Sphaerium* the beaks are nearly central in location, which serves to distinguish the members of this genus from those of *Pisidium,* in which the beaks are terminal, or nearly so.

Occurrence: Common in Crooked Creek, and in the swamps along the borders of the stream.

EXPLANATION OF FIGURES

PLATE 1

Fig.
1. *Deroceras gracilis* Rafinesque x 1/3 (Cat. No. 974)*
2. *Menetus exacuous* (Say) x 6.6 (Cat. No. 960)
3. *Helicodiscus parallelus* (Say) x 6.6 (Cat. No. 964)
4. *Gyraulus parvus* (Say) x 6.6 (Cat. No. 961)
5. & 6. *Hawaiia miniscula* (Binney) x 6.6 (Cat. No 963)
7. *Vallonia parvula* Sterki x 6.6 (Cat. No. 971)
8. *Physa hawni* Lea x 3.3 (Cat. No. 962)
9. & 10. *Gastrocopta cristata* x 6.6 (Cat. N. 968)
11. *Gastrocopta armifera abbreviata* (Sterki) x 6.6 (Cat. No. 965)
12. *Pupoides marginatus* (Say) x 6.6 (Cat. No. 970)
13. *Vertigo ovata* Say x 6.6 (Cat. No. 969)
14. *Gastrocopta procera mcclungi* (Hanna & Johnston) x 6.6 (Cat. No. 967)
15. *Gastrocopta tappaniana curta* (Sterki) x 6.6 (Cat. No. 966)
16. *Physa anatina* type x 3.3
17. *Lymnaea dalli* Baker x 6.6 (Cat. No. 958)
18. *Lymnaea parva* Lea x 6.6 (Cat. No. 956)
19. *Lymnaea humilis rustica* Lea x 3.3 (Cat. No. 957)
20. *Lymnaea builmoides cockerelli* Pilsbry & Ferris x 3.3 (Cat. No. 955)
21. *Lymnaea builmoides techella* Haldeman x 3.3 (Cat. No. 954)

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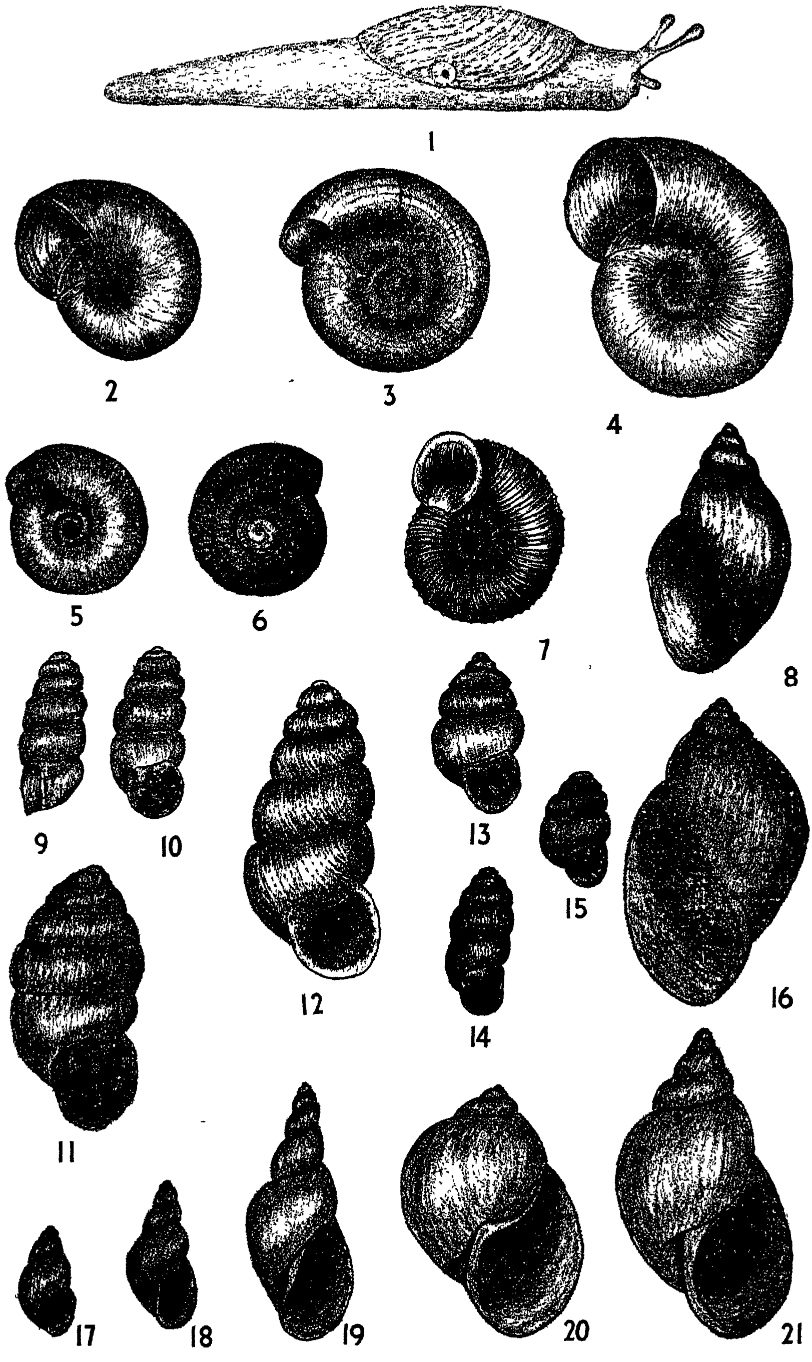
*Numbers refer to the catalogue of the mollusca in the Kansas University Museum of Natural History.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Pisidium fabale Sterki, Plate 2, Fig. No. 28, 29

This small pelecypod is less than a quarter inch in length. The beaks are placed in a terminal position, giving the shells an almost triangular outline.

Pisidium compressum Prime

This pelecypod is very similar to *Pisidium fabale,* although perhaps more nearly triangular in outline. Since the genus *Pisidium* is in a state of taxonomic chaos, it is difficult to determine the species with any degree of certainty.

Occurrence: Both species of *Pisidium* are common in Crooked Creek and both are especially numerous in the small spring-fed brooks in the Meade County State Park. These species also occur in creeks and small ponds throughout the area.

GASTROPODA

Lymnaea bulimoides techella Haldeman, Plate 1, Fig. No. 21

This snail has a shell of 7 whorls, somewhat shouldered and angular. The spire is elongate and conical, the body whorl composing at least half of the total height of 16-17 mm. The aperture is elliptical, with the reflected lip reducing the umbilicus to a small chink.

Occurrence: *Lymnaea bulimoides technella* is common in the sink-hole ponds, although erratic in distribution. It is able to survive periods of drouth, and sometimes appears in great numbers in a pond that has been dry the previous season. It is also common on grassy marshes.

Lymnaea bulimoides cockerelli Pilsbury and Ferris, Plate 1, Fig. No. 20

Lymnaea bulimoides cockerelli has a shell composed of 4½ whorls, the spire very short and flat, the body whorl very obese. The elliptical aperture is provided with a thin lip, which is flattened and reflected over the umbilicus. The short spire and very obese body whorl serve to distinguish this species from other Lymnaes.

Occurrence: *Lymnaea bulimoides cockerelli* was taken from a single locality, No. 10, which is a sink hole pond that is dry in arid periods. While it was not found in large numbers, it seems to persist here from season to season, in spite of the ephemeral condition of the pond.

Lymnaea parva Lea, Plate 1, Fig. No. 18

Lymnaea parva is a small snail, the shell about 5 mm. in height. The spire is elongate conical; the body whorl large and convex. The aperture is ellipitcal; its inner lip broadly flattened and reflected over the umbilicus, forming a chink at the opening. The horn colored shell is composed of about 5 whorls.

Occurrence: *Lymnaea parva* is rarely found in the water; rather it seems to prefer moist places not actually submerged. It is numerous in the moist meadows near marshes in the Park area, and in other stimilar situations throughout the two counties.

Lymnaea humilis rustica Lea, Plate 1, Fig. No. 19

The shells of this species are about 6 mm. in height, slightly larger than *Lymnaea dalli.* The spire is sharply conical; the whorls number about 5½. The inner lip of the nearly rectangular aperture is reflected over the umbilicus, reducing it to a mere chink. The color is usually a light amber, although the color varies somewhat with the character of the water in which the snails live.

Occurrence: This species is found sparingly in grassy pools, and in the moist meadows around marshes. Occasional specimens may be found in brooks.

Lymnaea dalli Baker, Plate 1, Fig. No. 17

Lymnaea dalli is a tiny form of *Lymnaea,* the smallest known in America; its height seldom exceeds 4 mm. or about one-sixth inch. The 4-5 whorls are rounded and strongly shouldered; the spire and aperture are about of equal length; the oval aperture is provided with a thin lip, which is reflected over the umbilicus. The color is greenish white to light amber.

Occurrence: This small snail, although belonging to a genus in which most of the species inhabit the water, is rarely found submerged. It prefers living on wet ground among sedges and grass, and it was found in numbers on the marshy ground around the ponds at Meade County State Park. Here it was associated with *Lymnaea parva, Succinea concordalis,* and *Vertigo ovata.*

Helisoma trivolvis (Say), Plate 2, Fig. No. 30

This is the largest of the planorbid snails, not only of this region, but of Kansas; it often measures nearly an inch in diameter, but the shells of western Kansas average smaller than this. It is reddish to light brown in color; spire depressed below the body whorl, and flattened; the aperture irregularly rounded and on the same plane as the body whorl. The umbilical opening is small and deep. The surface is embellished with closely spaced growth lines, visible without magnification. The body whorl is often carinate above, but this is not a constant feature.

Occurrence: *Helisoma trivolvis* is a most successful snail in this area, and the large numbers of fossil shells in Pleistocene beds of the region attest to the large populations of this snail that have lived here in previous times. It thrives in the temporary sinkhole ponds as well as more permanent bodies of water. It can survive long periods of drouth, apparently by burrowing into the mud in the bottom of drying pools.

Menetus exacuous (Say), Plate 1, Fig. No. 2

Menetus exacuous is a small planorbid snail, the shell is yellowish brown, the spire much flattened and slightly indented. The last whorl, which angles downward near the aperture, is convex except at the periphery, where it is drawn out to a thin, sharp edge. The umbilical pore is deep, and reveals all the whorls. Rather crowded growth lines cover the surface. *Menetus exacuous* somewhat resembles *Gyraulus parvus,* but may be distinguished by its flattened whorls, and the thin periphery.

Occurrence: *Menetus exacuous* was found only in the cool waters of No. 1 brooder pond at the Fish Hatchery, where it lived on the luxurious growth of pond weeds these ponds contain.

Gyraulus parvus (Say), Plate 1, Fig. No. 4

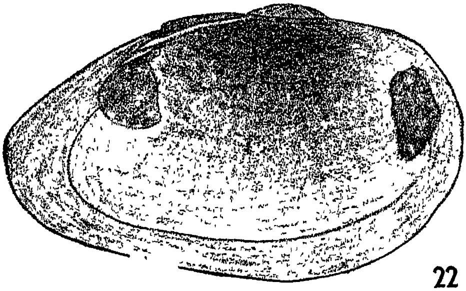
This small planorbid shell is a yellowish brown, 2-3 mm. in diameter, much depressed, and the embryonic whorls are usually indented. The umbilicus is wide and quite shallow, disclosing all the whorls. The surface is marked with fine growth lines. The aperture is simple and thin, and on the same plane as the body whorl. The periphery of the last whorl is bluntly rounded, unlike *Menetus exacuous,* in which the periphery of the body whorl is drawn out to a sharp edge.

Occurrence: *Gyraulus parvus* has been found only in No. 1 brooder pond at the Fish Hatchery at Meade County State Park. For several seasons only dead shells were recovered, leading to the belief that the artesian spring was bringing up fossil shells from Pleistocene beds below, but last season living

EXPLANATION OF FIGURES

Plate 2

Fig.	
22. & 23.	*Anodonta grandis* Say x ⅓ (Cat. No. 949)
24. & 25.	*Sphaerium solidulum* (Prime) ? x 3.3 (Cat. No. 951)
26. & 27.	*Uniomerus tetralasmus* (Say) x ⅓ (Cat. No. 950)
28. & 29.	*Pisidium fabale* Sterki x 6.6 (Cat No. 952)
30.	*Helisoma trivolvis* (Say) x 3.3 (Cat. No. 959)
31.	*Succinea concordalis* Gould x 3.3 (Cat. No. 972)
32.	*Succinea haydeni* Binney x 3 3 (Cat. No. 973)



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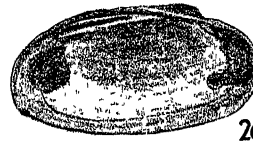

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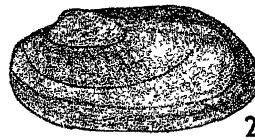

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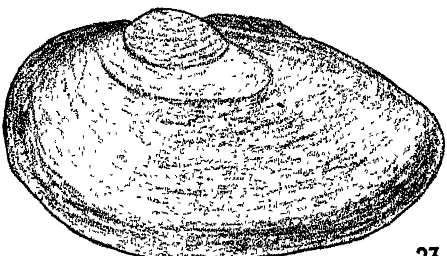

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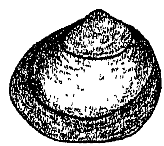

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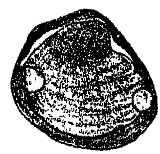

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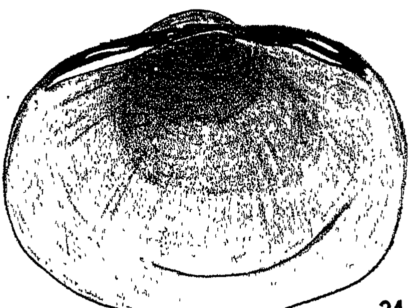

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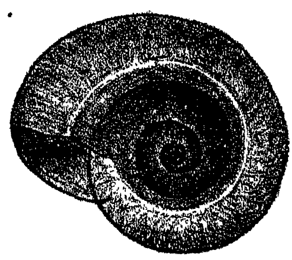

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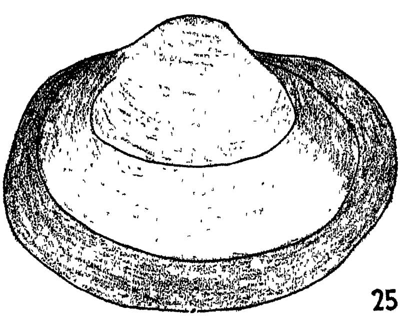

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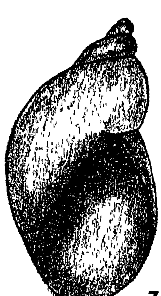

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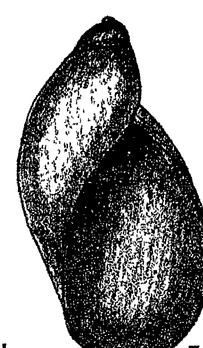

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individuals were discovered. Associated with *Gyraulus parvus* was the more numerous *Menetus exacuous.*

Physa hawni Lea, Plate 1, Fig. No. 8

Physa hawni has a heavy, irridescent shell, varying in color from yellow to brown, with occasional pink or reddish markings. There are 5½ whorls the spire is short and sharply pointed; the body whorl greatly enlarged. The aperture is elliptical, extending over one half the length of the shell. Shells of the genus *Physa* are the only spiral shells with the aperture opening toward the left. Some of these shells very closely resemble *Physa anatina.* This type is illustrated in Figure 16

Occurrence: *Physa hawni* occurs in nearly all the bodies of water found in the area, whether large or small, although it was not found in abundance in the spring-fed brooder ponds, it was common in the brooks which drained them. It is not uncommon to find *Physa hawni* thriving in stock tanks supplied from wells although there may be no natural bodies of water within miles.

Hawaiia miniscula (Binney), Plate 1, Fig. No. 5, 6

Hawaiia miniscula is a small snail with a shell less than ⅛ inch in diameter (2 mm.). The shell consists of four tightly coiled whorls which are flattened, especially above, the spire being depressed. The surface is marked with closely crowded growth lines, which give the hyaline shell a silky texture. The suture is well impressed. The umbilicus is wide and shallow, revealing all the whorls. There are no lamellae in the aperture.

Occurrence: This species is widely distributed over the area, being nowhere numerous. It withstands arid conditions successfully but is most numerous in wooded places where moisture conditions are better than on the treeless prairies.

Helicodiscus parallelus (Say), Plate 1, Fig. No. 3

This is a small yellowish white shell, about 4 mm. in diameter. The whorls are closely coiled, and all lie in a single plane. Growth lines are closely spaced and fused occasionally, forming distinct ridges. Raised lines parallel the whorls and cross the growth lines, giving the shell its specific name, and forming one of its distinguishing features. The umbilical pore is broad and shallow, revealing all the whorls.

Occurrence: *Helicodiscus parallelus* was first found in Clark County by Dr. C. W. Hibbard, and later he discovered it in extreme eastern Meade County, in a grove of cottonwood trees on the Wilson Ranch. It is rare in the region now, occurring sparingly around dead trees but in Pleistocene times it was common.

Gastrocopta armifera abbreviata (Sterki), Plate 1, No. 11

This subspecies of *Gastrocopta armifera abbreviata* has a waxy white shell about 4-5 mm. in height. There are 6-7 whorls, the body whorl being very large. The aperture is rounded, the lip thin and reflected. There are typically five lamellae, a fused angular-parietal, a large columellar, a small basal, and upper lower palatal. It can be recognized by these features, together with the whitish shell

Occurrence: *Gastrocopta armifera abbreviata* has a distinct preference for woodlands, although a single tree with dead wood about it is generally suffi-

cient to support a colony. It is often found in great numbers in small groves in which leaves and twigs have been allowed to accumulate.

Gastrocopta tappaniana curta (Sterki) Plate 1, Fig. No. 15

This species possesses an elongate spiral shell; it is opaque white in color, and is scarcely 2 mm. in height The denticles are variable in number, but there are usually 5 or 6. The parietal lamella is straight; other denticles usually present are collumelar, basal, upper and lower palatal

Occurrence: This small form of *Gastrocopta tappaniana curta* is rare in this area; a small series was found under some old bales of prairie hay in the meadows on the Park area.

Gastrocopta procera mcclungi (Hanna and Johnston), Plate 1, Fig No. 14

This amber colored shell has an elongate spire, the whole shell being scarcely 2 mm. in height. The aperture is rounded with a reflected, and greatly thickened lip, which serves to distinguish this subspecies from other forms of *Gastrocopta procera* The anguloparietal lamella is bifed, and usually there is a columellar, basal, upper palatal and lower palatal denticle, as well.

Occurrence: This snail is not common in the area; a small series was taken in Clark County in a wooded ravine.

Gastrocopta cristata, Plate 1, Fig. No. 9, 10

Gastrocopta cristata is a small pupillid snail about 2.5 mm. in height. The shell is amber colored, the spire turreted. The rounded oval aperture is provided with a widely reflected lip, within the aperture is a series of denticles, although all are inconspicuous except the parietal and columellar. Although this shell resembles *Gastrocopta procera* it may be distinguished from that shell by the presence of a distinct ridge which parallels the lip below.

Occurrence: *Gastrocopta cristata* is common in the grassy meadowlands of the Park area, and it occurs sparingly in similar situations elsewhere. It has never before been reported from the state.

Vertigo ovata Say, Plate 1, Fig. No. 13

Vertigo ovata is one of the smallest of the pupillids found in the area, the shell being scarcely 2 mm. in height. The shell is amber colored, and consists of 4½-5 whorls which are somewhat convex. The aperture is rounded except for the distinguishing notch on the outer lip, characteristic of most all the *Vertigos* This snail may be recognized by its shining amber color, the oval outline of the shell, and the typical five lamellae in the aperture.

Occurrence: *Vertigo ovata* is common, though not numerous in the moist grassy meadows of the Park area, and in similar areas elsewhere in the region. It can be found only by patiently searching close to the ground in deep growths of grass.

Pupoides marginatus (Say), Plate 1, Fig. No. 12

This small pupillid has a small shell with a turreted spire consisting of six whorls; its total length is about 5 mm. The shiny brown shell is easily recognized by the rounded aperture, devoid of lamellae, and the white, broadly reflected peristomal lip. The slightly shouldered whorls are marked by closely crowded growth lines.

Occurrence: *Pupoides marginatus* is widely distributed through the area, most commonly in wooded or grassy areas, but individuals may be found occasionally on arid sagebrush flats. This species is never found in colonies, unlike some other pupillids, such as *Gastrocopta armifera.*

Vallonia parvula Sterki, Plate 1, Fig. No. 7

Vallonia parvula has a small white hyaline shell about 2 mm. in diameter. The spire is but slightly elevated, the whorls are tightly coiled, and all are visible within the widely open umbilicus. The surface is embellished with regularly spaced membranous ribs. The last whorl angles downward near the rounded aperture. The peristome is broadly reflected and white in color.

Occurrence: This small species is very successful in this arid region; large numbers may be found in ravines which have even scant timber.

Succinea concordalis Gould, Plate 2, Fig. No. 31

The shell of this snail is about 6-7 mm. in height, thin, and composed of about 4½ whorls. The color is a reddish yellow. The spire is very small and turreted, the body whorl correspondingly is large. The aperture is elongate oval, extending well over half the length of the shell. *Succinea concordalis* is distinguished from *Succinea haydeni* by its smaller size, and the pointed spire of three whorls; in *Succinea haydeni* the bluntly rounded spire is composed of only 2 whorls.

Occurrence: *Succinea concordalis* is widespread in the area in grassy meadows as well as among the timber in ravines. It is never found in populous colonies like those of *Succinea haydeni.*

Succinea haydeni Binney, Plate 2, Fig. No. 32

Succinea haydeni is a thin shelled snail, of lustrous yellow color, and about 16 mm. in height. The embryonic whorl is scarcely visible, the second whorl small, while the body whorl is greatly enlarged. The aperture is long and oval, extending over half the length of the shell. *Succinea haydeni* closely resembles *Succinea retusa.*

Occurrence: This snail thrives on the moist marshes and borders of the pools in the artesian basin, where it is frequently found on watercress *(Nasturtium officianale).*

Deroceras gracilis Rafinesque (?), Plate 1, Fig. No. 1

This slug is about an inch long (25 mm.). The color varies from light to dark gray. There are no distinguishing marks on the slug. The mantle is small and oval in shape.

Occurrence: It is locally abundant in marshes, and most other shaded places. It is not widely found.

LITERATURE CITED

FRANZEN, DOROTHEA S., and LEONARD, A. BYRON, 1942 A Preliminary Survey of the Mollusca of Kingman County, Kansas. Trans. Kans. Acad Sci. 45:334-343.

HANNA, G. DALLAS, 1909. Mollusca of Douglas County, Kansas. Nautilus 23: 81-82 94-96

SCAMMON, R. E., 1906. The Unionidae of Kans. Kans. Univ Sci. Bull. III, No. 9: 279-373.

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Comments on G. Jan's Papers on Venomous Serpents and the Coronellidae

HOBART M. SMITH, University of Rochester, Rochester, New York

In 1859 Professor Jan published a work entitled "Prodome d'une Iconographie Descriptive des Ophidiens et description sommaire de nouvelles espèces de serpents venimeux." It contains 32 consecutively numbered pages of descriptive matter, three plates numbered 4, 5, and 6, and five other plates lettered A to E inclusive (A and B in color). The work bears the imprint "Paris, Imprimerie de Mme. Ve. Bouchard-Huzard," and thus would appear to have been separately published; inside the cover leaf, however, is the qualification "Extrait de la Revue et Magazin de Zoologie 1858 et 1859."

The article referred to in the journal cited is not, however, exactly reprinted in the 1859 work; in fact, there are so many discrepancies between the two that the original and presumed reprint must be considered as separate works. Since they include original descriptions of numerous new species of poisonous reptiles, a comparison of the two may be of value, particularly since generally both are not available at the same time.

The original article was published in four parts, two in the 1858 volume and two in the 1859 volume of *Revue et Magasin de Zoologie.* All parts bear the title "Plan d'une *Iconographie descriptive des Ophidiens* et Description sommaire de nouvelles espèces de Serpents." The first part (October) extends from p. 438 to the middle of p. 449; it contains an introductory letter from Aug. Duméril, extending to the top of p. 442; the remainder is Jan's introduction to the work. The entire first part is omitted in the "Prodrome."

The second part (December, 1858) extends from p. 514 to 527 inclusive, and is reprinted entirely (except for title) in the "Prodrome," in which it occupies pp. 3 to 16 (first paragraph only on p. 16); pp. 1-2 are the title page and reverse of same. There has been some shifting of type, but otherwise there are no changes:

"Prodrome"	"Plan"
p. 3, 4th line from bottom	begin p. 515
p. 4, 2nd line from bottom	begin p. 516
p. 6, first line	begin p 517
p. 7, first line	begin p. 518
p. 8, first line	begin p. 519
p. 8, last line	begin p. 520
p. 10, first line	begin p. 521
p. 11, first line	begin p. 522
p. 12, first line	begin p. 523
p. 13, first line	begin p. 524
p. 14, first line	begin p. 525
p. 15, first line	begin p. 526
p 16, first line	begin p. 527
p 16, line 9	end p. 527

The third part (March, 1859) extends from the middle of p. 122 to the top of p 130. The first page is omitted entirely in the "Prodrome;" this includes

a correction to "Espèces africaines" on p. 518 (p. 7 of the "Prodrome"). Beginning with the top of p. 123, all of the original is reprinted in the "Prodrome." The pagination is again varied by shifting of type, but there appear to be no other changes, except as noted below. A comparison of pagination follows.

"Prodrome"	"Plan"
p. 16, line 10	begin p. 123
p. 17, line 13 (3. *Ps. squamulosus*)	begin p. 124
p. 18, line 14 (toutes)	begin p. 125
p. 19, line 15 (possède)	begin p. 126
p. 20, line 15 (et)*	begin p. 127
p. 21, line 16 ([tou]che)	begin p. 128
p. 22, line 16 (est)	begin p. 129
p. 23, line 16 ([e]cailles)	begin p. 130
p. 23, line 17	end p. 130

*This and line 16 are one line in the original.

The fourth part (April, 1859) extends from near the middle of p. 148 to the middle of p.157 and, with the exception of the title, is reprinted in its entirety in the "Prodrome." The pagination may be compared as follows:

"Prodrome"	"Plan"
p. 23, line 18 (Les Serpents de mer)	begin p. 148
p. 24, line 7 (7. *H. fasciatus*)	begin p. 149
p 25, line 8 (dans)	begin p. 150
p. 26, line 8 (caudales)	begin p. 151
p. 27, line 7 (Division)	begin p. 152
p. 28, line 6 (Bord)	begin p. 153
p. 29, line 5 (xxv)	begin p. 154
p. 30. line 4 (*a.* Des)	begin p. 155
p. 31, line 4 (espèce)	begin p 156
p. 32, line 3 (Milan)	begin p. 157

The "Plan" is accompanied by three plates only, bearing the numbers 4, 5, and 9. In the "Prodrome" the last plate is renumbered 6 instead of 9, and the explanation of the plates (p. 32, "Prodrome") reads "Pl. vi" instead of "Pl. ix" as in the "Plan." The five important plates lettered A to E inclusive, of the "Prodrome," were not included in the original article, and even in the "Prodrome" there are no explanations of them save those printed on the plates themselves.

I am indebted to Dr. E. H. Taylor for the loan of a copy of the "Prodrome," and for some information concerning a somewhat similar situation in regard to the paper on the "Coronellidae." The original of this paper was published under the title "Enumerazione Sistematica degli Ofidi appartenenti al Gruppo Coronellidae" and appeared in the *Archivio per la Zoologia* [*l'anatomie e la fisiologia*], vol. 2, fasc. 2 (March 31, 1863), pp. 211-330. The separate is entitled "Prodrome della Iconografia Generale degli ofidi per il Prof. G. Jan Direttore del Civico Museo di Storia Naturale a Milano. II.a Parte VI.o Gruppo. Coronellidae;" its pages are numbered from 1 to 120. The separate also was published in 1863. Page 1 of the separate corresponds to p. 211 of the original; the first and last words of each page are the same in both the reprint and the original, and from this it is assumed that no changes were made in the text of the original, aside from page numbers.

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Notes on the Mansfield Museum's Mexican Reptiles Collected by Wilkinson

HOBART M. SMITH and M. B. MITTLEMAN, University of Rochester, Rochester, N. Y., and New York, N. Y.

The herpetological collections made by Edward Wilkinson in México, chiefly in Chihuahua, have been the subject of a number of scattered notes as well as two papers by E. D. Cope (1879: 261-263; 1885: 282-287). The museum at Mansfield, Ohio, founded by Wilkinson (Smith and Mittleman, 1943, Amer. Midl. Nat., in press) contains a number of specimens not hitherto reported.

Present are 9 species of snakes, numbering 55 specimens, and 10 species of lizards, numbering 192 specimens. There are no amphibians. The specimens are, for the most part, in glass-stoppered museum jars, amply supplied with formalin or alcohol, or both. Some are faded by long exposure to light, but most of them are in fair condition. They are labelled solely by means of cardboard tags, attached to wire supports that in turn are either loosely or firmly attached to the bottles. Through the years some transfers of labels have taken place, but these have been obvious for the most part, as apparently the only other herpetological material in the collection is from Ohio and Florida. Some specimens are associated with U. S. National Museum tags, and belong in the series sent by Wilkinson to the Museum for study by Cope. The entire series was catalogued upon receipt, and later a part of it was returned to Wilkinson. No records of the species returned was made.

To Mr. Fred E. Elder, Curator, and Mr. F. Thane Shaw, Custodian, we are much indebted for permission to study the collection at the museum.

Anolis nebulosus (Wiegmann)

A single, juvenile specimen, in poor condition, is from Batopilas, collected in 1875. It, or others like it, have been mentioned previously by Cope (1879: 261). So far as we can determine (the specimen very desiccated), it is referable to this form.

Holbrookia maculata approximans Baird

A series of 19 specimens, all labelled "Chihuahua, 1885", are of special interest. Although on the whole we believe them closer to *approximans* than to *dickersonae*, we are of the opinion that they are intermediate between the two, and that the latter should be known as *Holbrookia maculata dickersonae*.

Schmidt (1922: 724) lists *dickersonae* from Castañuelas and Alamo de Parras, in Coahuila. Smith (1935: 188) lists the form from Avilco, Conejos, and near Bermejillo, Durango and from Torreón, Coahuila. Additional specimens of *dickersonae* have been taken at Hipólito, Coahuila, by the senior author. The U. S. National Museum has examples from Gómez Palacio in Durango; Agua Nueva, Jimulco, and Saltillo, all in Coahuila; from Jesus María, in San Luis Potosí; and two from Berriozabal, Zacatecas. Thus Conejos, Durango, is the northernmost locality known for the species.

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The southernmost record for *approximans* in Chihuahua is Cope's record (1885: 282) for the city of Chihuahua, based on four specimens taken by Wilkinson. However, as in other cases, there is no certainty that the specimens so recorded were actually taken at or near the city. They may well have been taken farther south. Those in the Wilkinson collection very probably came from some place between the ranges of *approximans* and *dickersonae,* because they are intermediate in their characters.

The accompanying table presents data which appear to confirm this intermediate nature, assuming as typical Schmidt's (1922: table 1) and Smith's (1935: 189-190) comparative measurements and ratios for *approximans* and *dickersonae.* In the latter, the largest known specimen measures 72 mm. snout to vent (male), while the average length is 59 mm. in adult males and 58 mm. in females; in *approximans* the largest known specimen measures 61 mm. snout to vent (female), while the average length is 49 mm. in adult males, 51 mm. in females. The Chihuahua specimens are intermediate, the largest measuring 63 mm. snout to vent (male), and adult males average 59 mm. in length, adult females 49 mm.

Table of Variation in *H. m. approximans* (in mm.)

	Tail L.	Body L.	Total L.	Ratio Tail/Total
♂	49-*53.4*-59	52-*58.8*-63	101-*112.2*-122	46%-*47 6%*-49%
♀	36-*38.6*-42	45-*49.4*-54	82-*86.1*-97	42%-*43.3%*-44%

Of the 19 specimens, two females have no ventrolateral dark bars, one female has only a single bar on each side, and the remainder of the specimens have two bars. In no case are the blue areas visible, having long since faded.

In tail/total length ratio and in the number of ventrolateral bars, the Chihuahua specimens are like *approximans;* in size only are they like *dickersonae.* Yet it must be noted that one of us (Smith: *op. cit.*) has pointed out that numerous specimens of *dickersonae* possess only two of the dark bars, as do nearly all *approximans.* Thus it may be that the two bars possessed by most of the Chihuahua specimens are indicative of an equal degree of relationship with *dickersonae.* It is unfortunate that one of the most important characters, the extent of the blue patches surrounding the belly spots, cannot be utilized in this case, due to fading.

Two specimens bear U. S. N. M. No. 14310.

Holbrookia texana (Troschel)

Thirty-seven specimens of this species are in the collection. All are labelled "Chihuahua, 1885".

Crotaphytus collaris baileyi Stejneger

Four examples are in the collection, all of them badly faded and poorly preserved, although they are still identifiable with this race, as defined and described by Van Denburgh (1922: 106). One specimen, in slightly better condition than the others, measured 95 mm. from snout to vent, tail 209 mm., hind leg (from insertion to tip of 4th toe, exclusive of nail) 86 mm., femoral pores 17-18; as in other examples of this subspecies, there are two rows of interorbital scales between the supraocular series. All specimens were collected in "Chihuahua, 1885".

Phrynosoma cornutum (Harlan)

Nineteen specimens are of this species. All are well preserved. Three bear

U. S. N. M. number 14252, 14300, and 14228. The entire series is from "Chihuahua, 1885."

The distribution of this species in México has not heretofore been summarized in detail. Specimens we have examined, and literature records we believe valid, are as follows:

Sonora: Los Nogales.

Chihuahua: Río Santa María, near Progreso; east of Casas Grándes; 27 miles N of Ascención; 12 miles E of San Buenaventura; 6 miles S of Camargo; White Water at Boundary Monument No. 61; Lake Santa María; Santa Rosalía; Casas Grandes; Montezuma; Jiménez; Chihuahua [City]; 5 miles N of Montezuma; Batopilas.

Coahuila: Monclova; San Pedro; Castañuelas; Alamo de Parras; Músquiz; Patos, Sabinas.

Nuevo León: Monterrey; Pesquería Grande; 20 miles S of Nuevo Laredo; 20 km. N of Monterrey; Santa Caterina.

Tamaulipas: Matamoros; Charco Escondido; Alta Mira; Mier; Soto la Marina.

Durango: 7 miles S of La Loma; 25 miles N of Bermejillo.

The Mexican range of *Phrynosoma cornutum* may be outlined as extending from northern Sonora to northern Durango, and west through Coahuila and Nuevo León to northern Tamaulipas.

Phrynosoma modestum Girard

An excellent series of 52 specimens, mostly adults, is in the collection. The smallest, doubtless new-born, has a body length of 20 mm., and tail 9 mm.

Since Stejneger and Barbour (1939: 75) as well as Van Denburgh (1922: 432) mention only that this species occurs in northern Mexico, it is desirable to outline its Mexican range more clearly. We have examined or have seen records of specimens from the following Mexican localities:

Chihuahua: 11 miles S of Ahumada; Río Santa María, near Progreso; 110 miles N of Chihuahua [City]; near Janos; Juárez; Lake Santa María.

Coahuila: Saltillo; San Pedro; Parras; Monclova; Castañuelas; Agua Nueva; Alamo de Parras; Buena Vista; Río Nazas; Músquiz.

Nuevo León: Pesquería Grande; Santa Caterina

Sonora: Sierra de la Nariz; Los Nogales; Nariz Temporal.

Durango: 25 miles N of Bermejillo; 7 miles S of La Loma; between Lerdo and La Goma; Pedriceña; 5 km. W. of Torreón, Coahuila.

Zacatecas: 3 miles W of La Colorada.

San Luis Potosí: Hacienda la Parada.

Thus the range in México of *Phrynosoma modestum* may be briefly stated to extend from central Sonora south to central Zacatecas and northern San Luis Potosí, and east to central Nuevo León.

Sceloporus clarkii clarkii Baird and Girard

Four specimens are labelled "Batopilas, Chihuahua, 1875". There is no special reason to doubt these data, as there is no other place known where Wilkinson collected that *clarkii* might be expected. These specimens furnish the first record of the species from the state of Chihuahua. They are not *S. c. boulengeri,* for the femoral pores number over 10 in all specimens except on one side of one; the actual counts are 10-11, 11-12, 11-12, 14-14.

Sceloporus undulatus consobrinus Baird and Girard

Sixteen specimens are from "Chihuahua, 1885". These agree with other specimens examined from the state of Chihuahua. By their large size and heavy pigmentation ventrally (in males) they appear somewhat different from United States specimens. ,They bear U. S. N. M. tags number 14325, 14304, 14304.

Urosaurus unicus (Mittleman)

Probably of greatest interest in the collection is one juvenile specimen of this species; it consitutes the only second specimen known. Mittelman (1942: 172) has pointed out that the type locality of this species is properly restricted to Batopilas, Chihuahua; this second specimen is apparently of the same provenance.

The specimen is in rather poor condition, having suffered unduly from a combination of improper preservation and lack of care. Nonetheless, it is sufficiently well preserved to afford easy study. In view of the paucity of information on the variation of the species, we append the following notes.

Female. Snout to anus, 28 mm.; head length, 7.5 mm.; head width, 5.5 mm.; tail broken off at base; hind leg (insertion to tip of 4th toe, exclusive of nail), 17 mm. Frontal entire. Vertebrals extending onto the basal portion of the tail for a distance subequal to the length of the feur. Enlarged dorsals commencing caudad of a line joining the posterior points of insertion of the fore limbs; enlarged dorsals smaller than enlarged femorals, and about equal to the enlarged tibials. External to the enlarged dorsals, on the back, a sparse, interrupted series of enlarged scales, subequal to the enlarged dorsals. On the dorsolateral, lateral, and ventrolateral areas, four longitudinal series of enlarged scales and clusters of tubercles. Basal caudal scales in whorls of three verticils each, of which the first is always prominently largest. Dorsal, gular, and abdominal scales largely pavemented. A prominent fold commencing behind the ear, and arching over and behind the fore limbs to meet the lateral fold (it is not at all certain whether these are true dermal folds, or simple superficial wrinkles due to preservation). No postfemoral dermal pocket present. Uniform light brown above, except for head and vertebral region, which are paler gray, or grayish brown (due to partial deterioration); uniform gray beneath.

On the basis of the type specimen and the additional topotype described above, *unicus* appears to be best distinguished as follows: the general lack of rugosity; the widespread tendency towards pavementation of the scales; the small size; the lack of postfemoral dermal pocket; the enlarged dorsals commencing caudad of a line joining the posterior points of insertion of the fore limbs; the form of the caudal whorls of scales, in which the scales of the first verticil are more than twice as large as those of the successive two verticils; enlarged dorsals equal to or larger than the enlarged tibials.

Cnemidophorus gularis scalaris Cope

Fifty-seven specimens are in the collection. Two are labelled "Batopilas, Chihuahua, 1875", while the others are marked "Chihuahua, 1885". The series includes adults and young, which show a pattern evolution recognizably different from that of *gularis gularis*. We believe a rather well defined race is represented by these specimens, for which the name *scalaris* Cope (1892: 47) is the earliest available (there are numerous other later names). This form

is similar to *g. gularis,* having enlarged postantebrachials, spots in the dark fields between the stripes, and males with a pink throat and blue belly. From *g. gularis* it differs essentially in coloration; in males, the field spots produce a barred pattern anteriorly; in the females, the spots remain small and confined within the dark field, and do not interrupt the longitudinal light stripes.

The range of *g. scalaris* is somewhat doubtful; its definition must await examination of the extensive series of these lizards present in various museums. We have examined forty-three specimens in Field Museum of Natural History, however, from Jiménez, Chihuahua [City], and Lake Santa María, *Chihuahua;* Jaral, *Coahuila;* and 5 km. W of Torreón, Coahuila, in *Durango.*

Eumeces obsoletus (Baird and Girard)

One large specimen, bearing U. S. N. M. number 14232, is in the collection, from "Chihuahua, 1885".

Thamnophis macrostemma megalops (Kennicott)

Twenty-four specimens, "Chihuahua, 1885", are in the collection. The specimens appear typical in pattern. Three specimens bear U. S. N. M. numbers as follows: 14296, 14296, and 14263.

Thamnohis rufipunctatus (Cope)

The Mansfield collection contains sixteen specimens of *rufipunctatus.* The variation of certain characters in this series is shown in the accompanying table. None has a postrostral. The anal is divided in one.

Variation in *T. rufipunctatus*

sex	scale rows	ventral	caudals	supral.	infral.	preoc.	postoc.	labials enter eye
♂	19-21-17	151	78	8-8	10-11	2-3	4-4	4-4
♂	19-21-17	161	77	8-8	11-11	2-3	4-4	4-4
♂	18-21-17	157	77	8-8	10-10	3-3	3-3	4-4
♂	19-21-17	160	78	8-8	10-10	2-3	3-3	4-5
♂	18-21-17	156	76	8-8	11-11	2-3	3-3	4-4
♂	18-21-17	166	79	8-8	10-10	2-2	3-3	4-4
♂	18-21-17	161	....	8-8	10-11	2-2	3-3	4-4
♂	20-21-17	159	79	8-8	10-10	3-3	3-3	4-4
♂	20-21-17	154	....	8-9	10-10	3-3	3-3	4-5
♀	21-21-17	154	68	8-8	10-10	2-3	3-3	4-4
♀	18-21-17	155	71	8-9	9-10	3-3	4-4	4-5
♀	19-21-17	155	....	8-8	10-10	3-3	3-4	4-4
♀	21-21-17	154	68	8-9	10-11	2-3	4-4	4-5
♀	20-21-17	160	....	8-9	10-10	3-3	3-4	4-5
♀	20-21-17	155	69	8-8	10-11	2-2	3-4	4-4
♀	19-21-17	147	71	8-8	10-11	2-2	4-5	4-4

These specimens seem typical in pattern; they have the anterior edges of the belly scales dark-stippled, the upper posterior edges of the supralabials dark, a median series of rather large blotches with which alternate two rows of smaller spots on each side. Five specimens bear U. S. N. M. number 14261; three have number 14288; and one specimen each has U. S. N. M. numbers 14281, 14282, and 14297.

With the above data, the table of comparisons of *rufipunctatus* and *melanogaster* (Smith, 1942: 120) may be revised as follows:

	rufipunctatus	*melanogaster*
Dorsal pattern	Upper row of spots distinct	No upper row of spots, lower row poorly defined
Ventral pattern	Irregularly mottled	Nearly all black, or a mid-ventral dark line
Head pattern (juv.)	Labials strongly barred, head mottled	Labials indistinctly barred, head not mottled
Preocular	Never single	Occasionally single
Labials enter eye	One (very rarely two)	Two
Dorsal scales	(18-21)-(21-23)-17	19-(19-17)-17
Ventrals	♀ 147-160 (16 counts)	♀ 137-153 (69 counts)
Caudals	♀ 65-71 (10 counts)	♀ 49-63 (60 counts)
Range	Durango to Arizona	México [City] to Durango and San Luis Potosí

Elaphe laeta laeta (Baird and Girard)

Three specimens are from "Chihuahua, 1885." One, a male, has 27-27-19 scale rows; 238 ventrals; anal divided; 97 caudals; 8-8 supralabials; 11-11 infralabials; 1-1 preoculars; 2-2 postoculars; 2-2-3 temporals.

Pituophis catenifer affinis Hallowell

Two specimens are from "Chihuahua, 1885." We believe that Klauber's suggestion (1941: 60) of the intergradation of *catenifer* and *sayi* through the medium of *deserticola* and *affinis,* respectively, is a very reasonable one. It agrees with our observations in the field as well as on a certain few museum specimens.

Salvadora hexalepis celeris Smith

A single specimen bearing the data "Batopilas, Chihuahua, 1875," is in the collection. It is a female with 198 ventrals, 74 caudals, 9-9 supralabials, 10-10 infralabials, preoculars and postoculars 2-2, 1st supralabial separated from posterior section of nasal, antepenultimate labial in contact with postoculars, and 2-2 loreals. The high number of ventrals and two loreals define *celeris.* It is not to be supposed that by so identifying this specimen we believe *h. celeris* and *h. deserticola* occur together at Batopilas, but rather that (1) the four *h. deserticola* may actually have been collected near Chihuahua [City]; (2) the *h. celeris* may have been collected west of Batopilas; or (3) if all are from Batopilas, some ecological segregation of the two races in that area is indicated. Since the exact provenance of none of the five specimens is assured, we feel justified in referring these specimens to the races with which their characteristics agree, regardless of the lack of more specific locality data.

Salvador hexalepis deserticola Schmidt

Four specimens bear the data "Batopilas, Chihuahua, 1875." One female has 185 ventrals and 73 caudals; three males have 182, 184, and 193 ventrals, and caudals 79, 78, and 81, respectively. All have 9-9 supralabials, the first separated from the posterior section of the nasal; the antepenultimate labial contacts the postoculars on both sides in three specimens, on one side in one; the infralabials are 10-10 in one, 11-11 in one, and 10-11 in two. The preoculars and postoculars are 2-2 in all. The loreals are single in all specimens (fused with nasal in one).

The species has been reported previously (as *Phimothyra grahamiae*) by Cope (1879: 262).

Pelamis platurus (Linné)

A single specimen in the collection is labelled "Panamá Bay, E. Wilkinson." This may have come from Panamá, or from some small bay, bearing that name, in Sonora. It is noteworthy that Cope (1879: 263) records the species from "the Gulf of California near Guaymas [Sonora]"; this specimen is not

now extant in the U. S. National Museum, but may well be the present "Panamá Bay" specimen. We may add, however, that a perusal of the maps and atlases available to us did not disclose any such locality as "Panamá Bay" along the Sonora coast.

Crotalus scutulatus scutulatus Kennicott

One headless skin from "Batopilas, 1875", appears to belong to this race. It has 23-27-21 scale rows, 168 ventrals, and 21 caudals. There are four black caudal bands; 31 rhombs on the body, each dark-edged, bordered by a light color, and light-centered. The U. S. National Museum has other specimens, possibly from this locality, and presumably collected also by Wilkinson. If the provenance of the skin described above is correct, it then constitutes the first record for *scutulatus* near the western slope of the Sierra Madre Occidental, south of extreme northern Sonora.

LITERATURE CITED

COPE, E. D. 1879. Eleventh contribution to the herpetology of tropical America. Proc. Amer. Philos. Soc., vol. 18, pp. 261-277.

———. 1885. Thirteenth contribution to the herpetology of tropical America. Proc. Amer. Philos. Soc., vol. 22, pp. 271-287.

1892. A synopsis of the species of the teiid genus *Cnemidophorus*. Trans. Amer. Philos. Soc., vol. 17, pp 27-52, pls. 6-13.

KLAUBER, L. M. 1941. [Review] Variations and relationships in the snakes of the genus Pituophis. Copeia, 1941, pp. 57-60.

MITTLEMAN, M. B. 1942. A summary of the iguanid genus *Urosaurus*. Bull. Mus Comp. Zool., vol. 90, pp. 100-181, pls. 1-16, text figs. 1-11.

SCHMIDT, K. P. 1922. A review of the North American genus of lizards Holbrookia. Bull. Amer. Mus. Nat. Hist., vol. 46, pp. 709-725, figs. 1-5, pls. 58-60.

SMITH, H. M. 1935. Notes on some Mexican lizards of the genus Holbrookia, with the description of a new species Univ. Kans. Sci. Bull., vol. 22, pp 185-201, pls. 27,28.

———. 1942. The synonymy of the garter snakes. (*Thamnophis*), with notes on Mexican and Central American species Zoologica, vol. 27, pp 97-123.

STEJNEGER, L. and BARBOUR, T. 1939. A check list of North American amphibians and reptiles. xvi, 207 pp.

VAN DENBURGH, J. 1922. The reptiles of western North America. Occ. Pap. Calif. Acad. Sci., vol. 10, pp. 1-1028, pls. 1-128.

35

Histological Observations on the Anterior Pituitary Gland

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INTRODUCTION

In recent years rapid progress has been made in the investigation of the endocrine glands with special emphasis being placed on the anterior pituitary. Much of the progress in the interpretation of the functions of this gland has been made since 1934 and practical applications of this information are being used every day.

Numerous workers (Corner '30; Riddle, Bates and Dykshorn '32; Collip, Selye and Thomson '33) have demonstrated a close functional relationship between the pituitary and the mammary glands. Branch and Moss ('38) found an abnormal litter mortality in the young of rats that had been fed nicotine. It occurred to us that this result might have been the consequence of a pituitary dysfunction which expressed itself in a deficient function of the mammary glands. Therefore in the experiment recorded in this paper the pituitary was carefully examined. The weights, litter mortality and the estrous cycle were recorded in an attempt to 'parallel the preceding experiment of Branch and Moss.

The anterior pituitary must be investigated with due attention being given to the phase or cycle of the gonads and gonaducts as the structure changes with the estrous cycle. It was with this in mind that the most stable period, diestrus, was chosen as the rat presents a rapidly changing morphologic picture in the pituitary due to the shortness of the estrous cycle.

PREPARATION

Twenty-two female rats (Mus norvegicus albinus) of the Sprague-Dawley strain were used in this experiment. At the age of 28-30 days, these animals were divided into experimental and control groups. Both groups were housed in the same room in which the temperature was controlled and automatically recorded. Both groups were fed at the same time and with equal amounts of food consisting of Purina dog chow as a basic ration and a supplement of celery, lettuce, carrots, whole wheat bread and milk. Both groups were handled by the same individuals throughout the experiment.

Eleven animals (hereafter referred to as the experimentals) were earmarked and given nicotine dilution by mouth. The nicotine ($C_{10}H_{14}N_2$)* was diluted to the point where 1/20 c. c. contained 0.5 mg. of nicotine. In the administration of the nicotine the animal was held in the hand with just enough digital pressure applied to the masseter muscle to cause the rat to open its mouth. The 1/20 c. c. of liquid was placed as far back into the pharynx as possible. It was found that when the dilution was ice cold, the animal swallowed the dose with no apparent discomfort. The dosage of the nicotine was given in the following steps:

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*The nicotine used was a Merck product bearing the label: 6751 Nicotine 'Merck'—Extra pure 4a—containing 99.5% to 100% nicotine. E. Merck 32420 Darmstadt, Made in Germany.

Beginning with 0.5 mg. per day, the dosage was increased 0.5 mg. every fifth day for the next fourteen days, ending with 2.0 mgs. On the sixteenth day, the dose was increased by 1.0 mgs. and this increase was made every fourth day for the next forty-six days ending with 13 mgs. per day. At this level the convulsions following the reception of the dose of nicotine became so severe that the dosage was cut in half and given twice a day at an eight hour interval. On the forty-seventh day, the dosage was started at 7.0 mgs. (14.0 mgs. per day) and increased 0.25 mg. every eighth day for the remainder of the experiment. The final daily amount of nicotine given was 28 mgs. The nicotine seemed to make the animals more docile and decidedly increased their sexual activity. The other eleven animals used as controls were given drops of water in place of the nicotine. The dosage continued until the animals were killed for examination of pituitaries.

WEIGHT RECORDS

Weight records were kept for each animal until it was bred. The weights were recorded to the tenth of a gram at weekly intervals for a period of thirteen weeks. Chart I shows the record for both groups. Chart II reports these readings in cumulative form. It can be seen that the control animals gained over the experimentals each group having had the same average weight at the beginning. Chart III shows the gain at weekly intervals for both experimental and control groups. These figures were obtained as a difference between the preceding and the succeeding weights of the animal. Upon inspection of the data it can be seen that in no case did the control animals lose weight from the preceding week, while the condition did occur in the experimentals. This record is significant in that it is an average of a group of animals under as nearly similar conditions as it is possible to have them. These findings do not agree with a report of Behrend and Thienes ('32) who reported that nicotine had no influence upon the weight of the female rat. Charts I and IV show the individual weekly gains in percentage of the initial weight thus putting all animals on the same basis. The interest here lies in the observation that more regularity is obtained when each animal is judged in terms of its initial weight. These charts again show the consistent gain of the controls over the experimentals. Smith ('30) performed hypophysectomies on rats which resulted in "no weight gains for at least a five month period." He has also shown that hypophysectomies on rats completely inhibit skeletal growth.

CHART I

WEEKLY WEIGHT RECORD (in grams)

Date	Experimentals			Controls		
	Weekly weight	Gain	% of initial weight	Weekly weight	Gain	% of initial weight
1-10	43.4			43.4		
1-17	59.8	16.4	37.7	59.4	16.0	36.8
1-24	75.7	32.3	74.4	70 7	27 3	62.9
1-31	102.1	58.7	135.2	100 8	57.4	132.2
2-7	112.6	69.2	159.4	113.3	69.9	161 0
2-14	122.1	78.7	181.3	121.6	78.2	180.1
2-21	132.2	88.8	204.6	138.4	95 0	218.8
2-28	143.0	99.6	229.4	150.3	106.9	246 3
3-7	143.6	100.2	230.8	154.4	111 0	255.7
3-14	153 6	110.2	253.9	163.1	119.7	275.8
3-21	163.2	119.8	276.0	170.3	126 9	292 3
3-28	176.9	133.5	307.6	188.1	144.7	333.4
4-4	189.0	145.6	335.4	202.0	158.6	365.4

CHART III
WEEKLY INTERVAL WEIGHT (IN GRAMS)

Date	1/10	1/17	1/24	1/31	2/7	2/14	2/21	2/28	3/7	3/14	3/21	3/28	4/4	Ave.
EXPER.														
None		17.6	12.5	31.4	12.2	6.6	7.8	15.2	10.0	11.0	10.0	12.0	9.0	12.94
R′		18.5	14.7	30.4	10.3	10.5	24.5	–11.5	9.4	–.1	6.5	14.2	17.5	12.07
R′L′		4.5	17 9	37.6	5.5	13.5	2.3	15.5	–3.8	3.0	9.0	16.0	16.0	11.41
R′L‴		19.3	16.8	29.2	10.8	12.2	0.8	13.2	–9.7	15.7	11 0	14.0	10.0	11 94
R′L″		16.2	15 9	29.8	8.1	8.0	9.8	8.7	2.5	5.0	8.5	12.5	11.0	11 33
R″L″		19 0	10.5	27.5	10.0	2.0	17.9	13.1	9.3	3.2	8.0	11.0	11.0	11.91
R″L‴		12.2	16 1	26.4	10.5	15.5	–1.4	10.2	5.2	0.0	14.0	22.5	4.5	11 47
R‴L′		20.1	13.2	12.5	5.0	6.8	13.7	12.2	3.7	12.6	9.0	16.0	13.5	11.52
L′		15.9	18.7	28.1	18.5	11.0	13 0	16.3	9.7	7.5	12.0	5.0	21.5	14.76
L″		15.8	18.7	16.2	0.3	10.0	14.2	12.6	–0 3	8.4	8.1	15 0	2.0	10.08
R″		21.4	19.7	30.1	13.5	8.5	9.1	13.3	8.1	5.5	9.5	12.5	17.0	14.01
Weekly Average		16.41	15.88	27.38	9.52	9.51	10.15	10.8	4 01	6.53	9.65	13.7	12.09	12 13
CONTROL														
None		8.0	12.0	28.9	12.3	3.3	17 4	9.1	6.3	7.2	6.0	19.5	14.5	12.04
R′		17.8	5.5	32.7	11.5	14.7	7.0	10.8	6.5	10 0	10.0	15.5	16.5	13.2
R′L′		1.7	21 0	32.8	16.2	5.0	19.9	9.1	3 0	8 0	5.5	17.5	16 0	12 97
R′L″		15.1	8.0	24.4	19.6	7.2	13.2	11.1	10.3	9.2	7.0	30.0	4.0	13.25
R′L‴		21.8	8.5	31.9	8.0	6.3	23.4	9.0	3.0	8.0	6.0	15.0	9.0	12.49
R″L′		18.3	12.2	32.8	1.8	18.5	19.2	12.8	2.0	19.8	5.7	17.0	17.5	14.77
R″L″		23.7	10.9	35.9	18 7	7.3	14.1	13.9	3 0	13.0	10.0	19.0	14 0	15.29
R‴L′		12.6	8.7	32.5	14.2	11.0	18 2	14.6	0 0	7.2	12.0	13.5	18 5	13.50
L′		18.7	12.2	24.6	12.0	3 0	17.0	19.2	0.4	3.4	8.0	15 0	17.0	12.54
L″		18.4	11.7	29.5	12.7	8.0	19.1	8.9	12 0	3.0	4.0	10.0	14.0	12.60
R″		20 7	13 3	24.5	11.1	7.5	16.2	11.8	1.5	4.5	5.0	23 5	15.5	12.92
Weekly Average		16.07	11.27	30.04	12.53	8 35	16 79	11.85	4.36	8.48	7.2	17.77	13.32	13.23

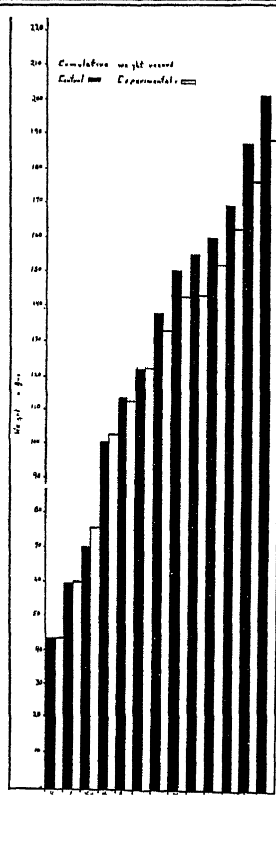
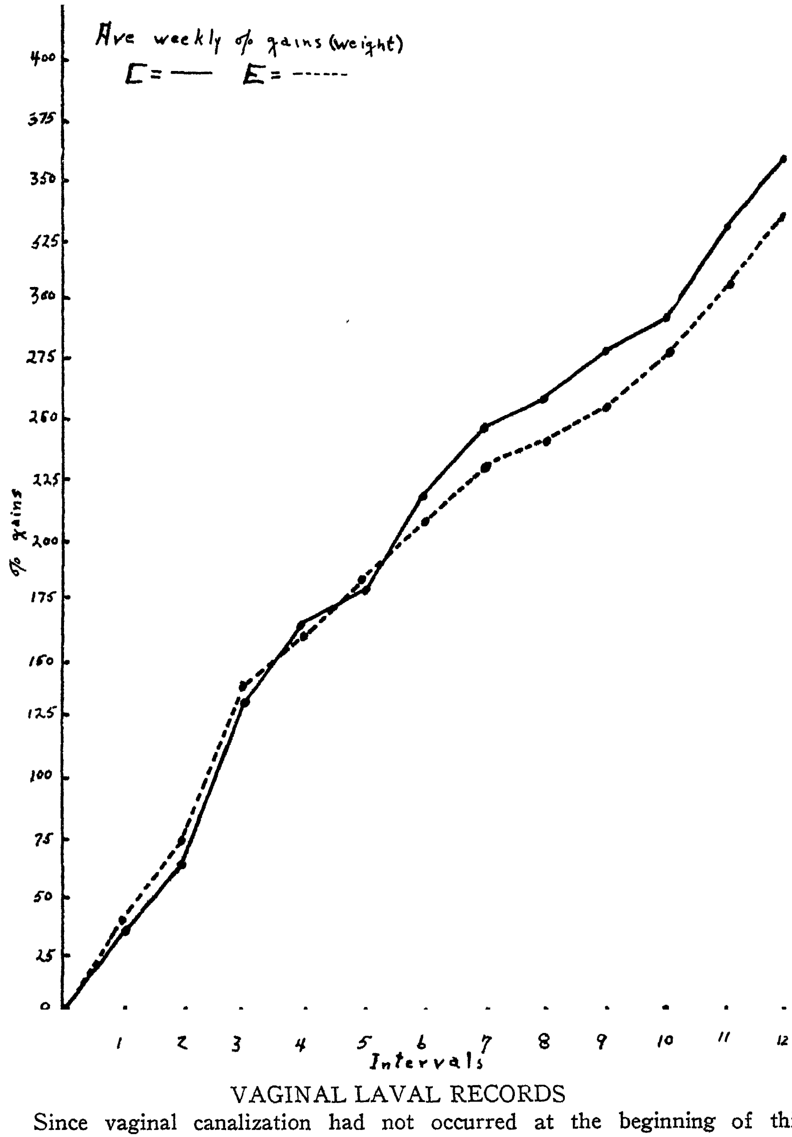


CHART II
CUMULATIVE WEEKLY WEIGHT RECORD
Data of Chart I

CHART IV
GRAPHICAL PERCENTAGE GAINS
Data of Chart I.



VAGINAL LAVAL RECORDS

Since vaginal canalization had not occurred at the beginning of this experiment, opportunity was offered to observe this particular event. Each female was examined each day to note the time when the canalization was established. In the experimental animals, the vaginal orifice was established at the average age of 60.2 days and the controls at the average age of 63.4 days. Both of these figures are lower than those given by Long and Evans

(Donaldson '24). Of interest here is the work of P. E. Smith and Earl T. Engle ('27) who show that maturity (and the opening of the canal of the vagina) could be affected within 36 hours, in 17 day old rats, with transplants of the pituitary gland; retardation by hypophysectomy in young rats (Smith '27).

In order to obtain a record of the estrous cycles, vaginal smears were taken each day beginning three days after the opening of the vagina, by the method described by Long and Evans (Donaldson '24). A vaginal spoon was used and the smear examined under a magnification of 75X. The number of cycles passed and the average time for each is recorded as follows:

	Number of rats	Number of cycles	Average days	Average days of cycle
Experimentals	11	99	51.1	4.6
Controls	11	78	60.5	5.5

This record is in fair agreement with Long and Evans (Donaldson '24). It is of interest to note that the cycle of the control rats is 0.9 days longer, on the average, than that of the experimentals. This fact is supported by Buel ('37). The work of Wilson and DeEds ('37) shows that nicotine affects the estrous cycle of rats and that it produces sterility or unhealthy offspring in some cases.

BREEDING AND LITTER MORTALITY

Females in proestrus or estrus were placed with males of the same age and stock, and left together for a period of 4 to 5 days, when they were returned to a separate cage. After a few days, the females which did not show an interruption in the estrous cycle were again placed with the males. When pregnancy was evident the vaginal smearing was suspended until after parturition. Three to five days prior to parturition, the females were placed in individual maternity cages where they remained until they were killed. They were closely watched in order to observe the condition of the young and the number born. The young of the experimental group were puny and apparently unhealthy as is evidenced by the following summary of the mortality record:

	Number of female rats	Number born	Number living	Number dying	Average wt. living
Experimentals	11	107	48	59	
Average		9.7	4.3	5.4	6.9 gms.
%			44.9	55.1	
Controls	11	97	92	5	
Average		8.8	8.35	0.45	7.42 gms.
%			94.9	5.1	

The record indicates that death occurred in 55.1% of the experimentals and in 5.1% of the controls. This result is confirmed by Wilson and DeEds ('37). There is also a significance in the weight differences in the surviving young as the control offspring were over 0.5 grams heavier on the average, at the time of sacrifice, than the young of the experimentals. This seems to agree with a similar experiment conducted by Essenberg et al. ('40). When female albino rats were subjected to inhaling cigarette smoke "that would approximate human smoking of about a package of cigarettes a day" it was found that the females were under weight and that "many of the young of this group were undersized and died early."

Each female was allowed to deliver her young and vaginal smears were again made. The animal was allowed to pass one estrous period and was killed in the succeeding diestrous period.

DISSECTION

The rats were killed with ether and decapitated to allow good drainage of blood. The pituitary was removed by the following technique. The mandible was removed and entrance to the brain case made through the foramen magnum. Two cuts were made by means of small bone forceps, through the basilar part of the occipital bone. By lifting the basal plate (Greene '35) a break would occur just posterior to the sphenoid bone. Then the basisphenoid was carefully removed, taking extreme precaution not to disturb the gland which lies against the flattened sphenoid bone, in its meningeal coverings (Wislocki '37). The cranial nerves were cut in order to free the brain and the entire brain was rolled out of the cranium. The reason for removing the entire brain with the pituitary was to avoid handling the pituitary with instruments and thereby macerating the gland. The lower left mammary gland, the adrenals and the thyroid gland were also removed from the animal and this material with the heads of the young was fixed in Zenker formol fixative.**

After all sacrifices were accomplished and the material fixed, the pituitaries (which had hardened) were removed from the brain and place in dioxane for dehydration and clearing. The embedding was done in paraffin with a melting point of 130°-132°F. The pituitaries were sectioned sagittally at a thickness of 5 microns. The sections were mounted serially and stained by the Mallory Azan method (Kirkman's modification).

THE PITUITARY GLAND

Of the more than six hundred significant contributions to pituitary physiology and cytology, almost one half have been published since 1932, when a brief chapter on the cytology of the pars glandularis appeared (Allen et al, '39).

This gland occurs in all vertebrates from the hagfish to man. It is because of its activity and its prevalence that it is important. Guyer ('41) refers to it as the "conductor of the endocrine orchestra". According to Denger (Donaldson '24) this gland ranges from 4.8 grams to 6.2 grams in female rats. After the 40th to 50th day the weight of the hypophysis of the normal femal albino rat increases markedly over that of the males when considered in relation to body weight.

The anatomical divisions of the hypophysis and their embryonic origins respectively are: (Van Dyke '36).

Pars glandularis	Rathke's pouch of buccal ectoderm.
Pars intermedia	Superior part of caudal portion of Rathke's pouch
Pars tuberalis	Paired lateral lobes at the ventronasal end of Rathke's pouch.
Pars neuralis	Infundibular process of the diencephalon.

As early as 1884, Flesch described chromophobes (non-staining non-granular cytoplasm) and chromophils (with demonstrable cytoplasmic granules).

In 1892 Schonemann (Van Dyke '36) recognized three types of cells in the pars glandularis.

**Zenker formol

Mercuric Chloride	5.0 gms.	Zenker Stock
Potassium Bichromate	2 5 gms.	
Distilled HOH	100.0 cc.	

Heat gently until dissolved

Add 10 c.c. of formalin to 100 c c. of Zenker stock immediately before use.

1. reserve cells (chromophobes, neutrophil, chief cells)
2. oxyphilic cells (eosinophils, acidophils, alpha cells)
3. basophilic cells (cyanophils, beta cells)

Sometimes these cells are classified simply as reserve cells, (chromophobes) and chromophilic cells (oxyphils and basophils).

CELL STRUCTURE AND CELL RELATIONSHIPS

The stains employed in this study caused the cytoplasm of the acidophils to appear a dark pink to a deep red. The cell possessed a clear or a blue nucleus. The cytoplasm of the basophils appeared a light blue to a heavy granular blue, the nucleus was amber to a deep red depending upon the state of secretion. The chromophobes took practically no stain at all.

Our foregoing observations are supported by a statement of Severinghaus, gathered from "Sex and Internal Secretions" (Allen et al. '39). "At the height of granule elaboration and storage, the nucleus becomes densely chromatic, and will stain intensely with aniline blue in the acidophile and with acid fuchsin in the basophile". Intense coloration persists through granule depletion, and chromophobes can be seen whose nuclei still retain the characteristic color of the acidophil or the basophil type. When the cell begins again to elaborate new secretory granules, the nucleus reorganizes into more delicate chromatin net work and loses its affinity for the aniline blue or fuchsin and stains only with haematoxylin. This haematoxylin staining persists until the cell has again attained its maximum granular content.

The first chromophil cell (Van Dyke '36) to be differentiated from the primitive undifferentiated (or reserve) cells in embryonic life is the oxyphil. In rabbits, sheep, oxen, hogs and man the basophils cannot be seen until after birth.

Many investigators still believe that the oxyphil and the basophil are morphologically different types of cells. There is much less agreement as to the relationship of the reserve cells to the chromophils.

Severinghaus (1933) on the basis of the golgi apparatus in the pituitary of the rat, concludes that the cells are of two types, one ultimately differentiated into an oxyphil cell, the other into a basophil.

"If we assume (Allen et al. '39) that the granules represent the precursors of the secretory product, then the elaboration, storage and loss of the granules are all to be regarded as phases of secretory activity, and any proportional shift in the anterior lobe cells becomes an indicator of the gland's secretory significance. Obviously here also lies the possibility of association of specific hormones produced by the gland with particular cell types." In the preceding statements it is assumed that the cellular progression is as follows:

$$\text{Chromophobes} \longrightarrow \begin{cases} \text{Basophilic Chromophobes} \rightleftarrows \text{Basophil} \\ \text{Acidophilic Chromophobes} \rightleftarrows \text{Acidophil} \end{cases}$$

The chromophobic cells appear to be resting cells. There is little if any evidence of mitotic activity in the adult pituitary according to Allen (et al. '39). Relatively few (Hunt '42) mitotic figures are found in the diestrous or proestrous pituitary of the rat. Therefore, these alterations must be the consequence of cellular reorganization rather than of mitotic proliferation.

According to Charipper and Haterius ('34) the anterior lobe of the pituitary of the estrous rat is predominantly basophilic, and that of the diestrous rat is

acidophilic. The changes brought about in the pituitary of a pregnant individual have been attributed to the internal secretion of the corpus luteum (Van Dyke '36).

In the attempts of investigators to associate every reproductive phenomenon with a certain type of cell, many assumptions have been made but only a few of these seem to be sufficiently supported. According to Van Dyke ('36) the oxyphilic cells are thought to elaborate the growth promoting hormone because: 1, the symptoms of the most clear cut disease of the pituitary in man, acromegaly, are apparently due to an excessive secretion of the growth promoting hormone by the oxyphilic cells of a tumor (adenoma) and 2, growth promoting effects may be produced by administrations of ox pituitary composed of oxyphilic and reserve cells. The view is generally held (Allen et al. '39 and Van Dyke '36) that the basophils specifically elaborate the gonadotropic hormones. Cytological changes (Van Dyke '36) in the pituitary of females at different stages of the estrous cycle also suggest that the oxyphilic cells secrete the follicle stimulating hormone. Also there seems to be a greater amount of gonadotropic hormone in the pituitary of the male rat than in that of the female. This difference may be related to the greater proportion of chromophils particularly the oxyphils in the pars glandularis of the male rat.

The first hint that a hormone of the pituitary body might effect the production of milk came from the experiment of Ott and Scott (Van Dyke '36). They found that an increased supply of milk could be withdrawn from the udder of a lactating goat immediately after the intravenous injection of an extract of the pars neuralis. Extracts of the pars neuralis, however, are probably not truly lactogenic; rather they seem to cause an emptying of the alveoli and ducts without furthering the secretion of milk. More important was the report of Stricker and Grueter '28 (Van Dyke '36) which states that lactation could be produced in the pseudopregnant rabbit, before or after spaying, by the injection of an extract of the pars glandularis. Moreover, by similar treatment a similar effect could be produced in a doe or bitch, both of which had ceased to lactate for ten days or more. Lactation cannot occur in a hypophysectomized animal.

Haterius ('32) found that the pituitary of lactation resembled that of the pregnancy in the rat, and that after weaning and the onset of estrus the oxyphil cells with homogenous cytoplasm rapidly disappeared. Thus it would seem that the pregnancy-like pituitary exists through lactation until the onset of estrus. This is not confirmed in the observations made here, although all rats were killed when lactation was at its height. A higher percentage of acidophils was observed than is reported in most literature for the cycle in which the pituitaries were obtained, but no resemblance to a pregnancy pituitary was observed.

It has been known for some time that the chief source of prolactin (Jeffers '35 and Allen et al. '39) is the anterior lobe of the pituitary and that its quantities vary with the stages of life and reproductive cycles. Schooley and Riddle, in unpublished data of '38, (Allen et al. '39) state that the elaboration of prolactin is accomplished by the eosinophil cells (oxyphils). This contention is supported by the data presented in the cell counts by the fact that the acidophils, in this experiment, presented a greater per cent of cells than in the majority of the significant data for the diestrous period in normal non-lactating females.

The pregnancy changes (Haterius '32) in the pituitary persist until just before the estrous cycle should be resumed normally. For this reason the rats were killed after the first normal estrus and at the first diestrus which is the longest stable period in which the pituitary could be obtained.

The size and shape of the cells is of interest. The largest acidophil cells are about 10 microns (Severinghaus '33) in greatest dimensions. They are usually round or ovid but not infrequently angular or elongated especially when lying grouped along a capillary. The largest basophils measure 25 microns (ibid.) in diameter. The individual cells are round, and tend to associate into polyhedral lobules. Since the chromophobes are the precursors of both the acidophils and the basophils, they must resemble these definitive types in size.

The regional distribution of the three cell types in the rat pituitary are as follows: The acidophils (Severinghaus '33) are most plentiful in the central portions of the glands and surrounding the intraglandular cleft. The basophils, on the other hand, are more peripherally located and are especially numerous at the lateral junctions of the pars intermedia with the anterior lobe. The chromophobes are found in groups quite regularly distributed throughout the gland. Our own observations confirm, in general, this arrangement of cells in the pituitaries of rats studied.

CELL COUNTS

In the cell counts referred to by Wolfe and Cleveland ('33) the following results were obtained for the normal diestrous female rat:

SUMMARY—Cell counts on anterior lobe of pituitary gland

	Acidophils		Basophils		Chromophobes	
Controls	Counted	%	Counted	%	Counted	%
R″	33165	42.50	3226	4.14	41503	53 28
L″	45626	42 25	4588	4.45	52862	51.28
R′L‴	21696	43.02	1940	3 84	26795	53 13
Totals	100487	43.42	9764	4 21	121160	53.36
Experimentals						
R′	37780	43.2	3919	4 25	45946	52 54
R‴L′	37127	45.6	3670	4.51	40609	49 88
R″	19104	41.61	1954	4 25	24814	54.09
Totals	94011	43.78	9343	4.25	111369	51 86

The figures in the record of which the above summary is a part, have been statistically checked for the standard and probable error and have been found sound.*

The similarities between the cell proportions of the pituitaries of the experimental and the control animals cannot be ignored. There is not a significant difference between them to warrant any statement to the contrary. This problem has been investigated by Moss, in a paper presented by Branch and Moss ('38), who found a difference in the proportion of the cells between the control and the experimental animals.

MAMMARY GLAND

As the anterior pituitary gland yielded no indication of a change in hormone secretion as an influence upon the mammary glands, it seemed advisable to check the mammaries for any evidence of change. The mammary glands of both the experimental and the control animals were fixed, embedded, sectioned and stained with both Harris haemotoxylin and Azo carmine stains. In each

*Dr. C. B. Read and assistant, University of Wichita, deserve credit for advice concerning the mathematical computations and for checking the results

instance the lower left nipple and the surrounding glandular material was used. Examination showed no significant difference between the experimental and the control mammaries aside from the variation that can be correlated with the functional acitivity of the glands. The females, whose litters had died, had lost the mechanical stimulus to the mammaries but milk was still present, (Selye and McKeown '34, Jeffers '35 and Van Dyke '39). The control animals having continued to suckle their young possessed this mechanical stimulus to the time of death and the glands possessed evidence of more secretion.

This evidence is not in accordance with the assumption of Branch and Moss ('38) who suggested that the cause of death in the litters of the experimental group was simple starvation. As this investigation reveals the presence of milk in the alveoli of the mammary glands of the females which had lost their young, the cause of excessive litter mortality will have to come from some other source. It is tempting to postulate that the death of the young may have been produced by a simple transfer of nicotine across the mammary barrier, making the milk distasteful or toxic.

SUMMARY

1. Female albino rats that were fed alkaloidal nicotine failed to make normal weight gains.

2. The age, at which the vaginal canals of the experimental rats opened was younger than that of the control rats. The period of the estrous cycle was shorter in the experimental rats than in the controls. Both of these facts seems to indicate an increased sexual activity in the experimental group.

3. The females, which were allowed to litter while being fed the alkaloidal nicotine, produced unhealthy and puny young and lost a high percentage of their young before the occurrence of the first diestrus following parturition.

4. There is no indication of a difference in the histology of the anterior pituitary gland between the experimental rats and the control rats.

5. Nothing in the examination of the histological preparations of the mammary glands would indicate a failure of lactation in the glands of the experimental animals.

BIBLIOGRAPHY

ALLEN, EDGAR, C. H. DANSFORTH and E. A. DOISEY: 1939. Sex and Internal Secretion. Williams and Wilkins Co.

BEHREND, ALLEN and C. H. THIENES: 1932. Chronic Nicotinism in Young Rats and Rabbits. Effects on Growth and Oestrus. Jour. Pharmacol. and Exper. Thearp. 46(1) 113-124.

BRANCH, HAZEL E. and W. GLENN MOSS: 1938. Effects of Nicotine on Rats (Albino). Trans. Kansas Acad. Science. Vol. 41, 317-329.

BUEL, F., W. BUEL, F. FIELDING, D. LITTLE, M. LITTLE and C. H. THIENES: 1937. Estrus and Reproduction in the White Rat as Influenced by Chronic Nicotinism. Jour. Pharmacol. and Exper. Therap. 60:100.

CHARIPPER, H. A. and H. O. HATERIUS: 1932. Histology of the Anterior Pituitary of the Albino Rat in Relation to the Oestrous Cycle. Anat. Rec. Vol. 54, 15-25.

COLLIP, J. B., H. SELYE and D. L. THOMPSON: 1933. Further Observations of the Effects of Hypophysectomy on Lactation. Proc. Soc. Exper. Biol. 30, 913.

CORNER, GEORGE W.: 1930. The Hormonal Control of Lactation. Amer. Jour. Physiol. Vol. 95, 43-55.

DONALDSON, HENRY H.: 1924. The Rat. Data and Reference Tables for the Albino Rat. Memoirs of the Wistar Institute of Anatomy and Biology. No. 6.
ESSENBERG, J. M., JUSTIN V SCHWIND and ANNE R. PATRAS: 1940. The Effect of Nicotine and Cigarette Smoke on Pregnant Female Albino Rats and Their Offspring. Jour. Lab. and Clin. Med. 25 (7) 708-716.
GREENE, EUNICE CHANCE: 1935. Anatomy of the Rat. Transactions of the American Philosophical Society. Vol. 27.
GUYER, MICHAEL F.: 1941. Animal Biology. Harper and Bros. New York.
HATERIUS, H. O.: 1932. The Relation of Pregnancy Cells in the Pituitary of the Rats to the Reproductive Cycle. Anat. Rec. Vol. 54, 434-551.
HUNT, THOMAS E.: 1942. Mitotic Activity in the Anterior Hypophysis of Female Rats. Anat. Rec. Vol. 82, 263-276.
JEFFERS, KATHARINE R.: 1935. Cytology of the Mammary Gland of the Albino Rat. Amer. Jour. of Anat. Vol. 56. Part I Pregnancy, Lactation, and Involution 257-274. Part II Experimentally Induced Conditions 279-299.
RIDDLE, OSCAR, ROBERT W. BATES and SIMON W. DYKSHORNS 1932. Pituitary Gland Secretion and Milk Production. Science Abstracts. Vol. 176 Aug. 12, 1932.
SELYE·H. and T. MCKEOWN: 1934. Further Studies on the Influence of Suckling. Anat. Rec. Vol. 60, 232-332.
SEVERINGHAUS, AURA EDWARD: 1933. A Cytological Study of the Anterior Pituitary of the Rat, with Special Reference to the Golgi Apparatus and to Cell Relationship. Anat. Rec. Vol. 57, 149-171.
SMITH, P. E.: 1927. The Disabilities Caused by Hypophysectomy and Their Repair. Jour. Amer. Med. Assoc. Vol 88, 158-161.
——— 1930. Hypophysectomy and Replacement Therapy in the Rat. Amer. Jour. of Anat. Vol. 45, 205-256.
1932. The Secretory Capacity of the Anterior Hypophysis as Evidenced by the Efforts of Partial Hypophysectomies in Rats. Anat. Rec. Vol. 52, 191-205.
SMITH, P. E. and EARL T. ENGLE: 1927. Experimental Evidence Regarding the Role of the Anterior Pituitary in the Development and Regulation of the Genital System. Amer. Jour. Anat. Vol. 40, 159-217.
VAN DYKE, H. B.: 1936. The Physiology and Pharmacology of the Anterior Pituitary Body. Vol. 1. The University of Chicago Press.
——— 1939. The Physiology and Pharmacology of the Anterior Pituitary Body. Vol. II. The University of Chicago Press.
WILSON, R. H. and FLOYD DEEDS: 1937. Nicotine Toxicity, Effects to Nicotine-Containing Diets on the Estrus Cycle. Jour. Pharmacol. and Exper. Therap. Vol. 59, 260-263.
WISLOCKI, GEORGE G.: 1937. The Meningeal Relations of the Hypophysis Cerebri. Anat. Rec. Vol. 67, 273-286.
WOLFE, J. M., and E. T. ELLISON: 1934. Morphological Difference in the Anterior Pituitaries of Male and Female Rats. Anat. Rec. Vol. 58, Supplement 93.
WOLFE, J. M., E. T. ELLISON and LOUIS ROSENFELD: 1934. Morphological Studies on the Anterior Pituitaries of Mature Female Rats Receiving Injections of Pregnancy Urine Extracts. Anat. Rec. Vol. 60, 357-367.
WOLFE, J. M., RUCKER CLEVELAND: 1933 Cyclic Histological Variations in the Anterior Hypophysis of the Albino Rat. Anat. Rec. Vol. 55, 233-249.
WOLFE, J. M.: 1935. The Normal Level of the Various Cell Types in the Anterior Pituitary of Mature and Immature Rats, and Further Observations on Cyclic Histologic Variations. Anat. Rec. Vol. 61, 321-330.

Science and the War

EDITOR'S NOTE. The nine papers (Nos. 37-45) which follow were presented at the seventy-fifth annual meeting as a special symposium. These papers, together with the explanatory foreword by the editor (No. 36), were preprinted and distributed to the general public as a special anniversary booklet in August, 1943. The nine papers and the foreword which immediately follow are identical with those issued in the anniversary booklet save for very minor alterations.

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The Kansas Academy of Science

Scientific societies through their meetings and publications constitute one of the many features of a civilized society. Such agencies have stimulated scientific thought and its application; have developed constructive criticism with resultant gains in the quality of scientific achievement; have suggested new fields for intellectual exploration; and last, but by no means least, have provided fruitful companionship for like-minded individuals.

These like-minded individuals, the members of the several scientific professions, have long been the object of public concern. To be sure, this concern is as respectful as that accorded most magicians; but also it is nearly always one of humorous despair, somewhat akin to the concern that the harried parent of an unusual child shows in trying to anticipate the offspring's unpredictable behavior.

This attitude of the layman is doubtless due in part to the serious interest displayed by the scientist in apparently trivial or obscure matters and in part to the penchant of the scientist in describing the results of such interest in long and ponderous words. When recital of dry facts and figures clothed in this cumbersome language is made at a scientific meeting, it is little wonder that ordinary individuals—meaning the banker, the grocer and the hot-dog vendor—regard the occasion as a good one to avoid and refer to our activities —if at all—with a slant-eyed condescension suggesting that we lack the human qualities possessed by ordinary persons.

But we are human, very human, as any patient observer could eventually determine. All that would be necessary to prove this point would be the courage to attend a scientific meeting, for here occasionally the tedium of the program will be broken by a brief turn in the tide of usual affairs, a turn revealing that, after all, the participants are ordinary mortals. A clash of opinion, an apparently wrong interpretation of evident fact, or an unjustified criticism will soon reduce the participants to a very ordinary human level, while the remainder of the scientific audience will look on with awakened interest and sometimes with scarcely suppressed glee.

Bret Harte, many years ago, described such incidents in poetry to call attention to the human aspects of the members of the profession and to rib us rather pointedly on the deadly seriousness with which we take ourselves and our affairs.

Poets, being concerned with fancy rather than fact, have paid little attention to scientists; and, it must be confessed, scientists know little about poets or poetry. Harte's efforts then, at least deserve mention in scientific literature, especially as they will aid in establishing our claims for consideration as human beings. Truthful James, a character of Harte's fertile imagination in his early California days, once attended a meeting of the "Academy of Natural Sciences at Smith's Corner, Tuolumne County." Harte, through Truthful James, describes the meeting at some length in verse; in fact, in nine verses. Even a trusting and naive scientist, however, suspects that the poetry is not great literature; but so seldom do we find ourselves in verse at

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all, that we follow line after line with a pleased, if self-conscious, satisfaction. It develops, as one follows Truthful James, that a Mr. Brown brought a sack of bones to a regular meeting of the Academy at Smith's Corner and delivered a learned paper describing the remains as those of some rare and ancient animal. After a cursory glimpse of the remains, however, a fellow member arose and remarked with caustic brevity that the bones belonged to one of his lost mules Not to be outdone at this turn of affairs, Mr. Brown dryly replied that he (Brown) had evidently been robbing his critic's family vault. Truthful James was deeply distressed at such unseemly deportment and his comment, the heart of the poem, constitutes a rule of conduct not ill-adapted to any scientific group:

> Now I hold it is not decent for a scientific gent
> To say another is an ass,—at least, to all intent;
> Nor should the individual who happens to be meant
> Reply by heaving rocks at him, to any great extent.

At this point, despite the restraining influence of Truthful James, the meeting broke up with so violent a row that the affairs of the Academy of Natural Sciences at Smith's Corner came to an abrupt end after a transitory existence of six months.

Fortunately for Kansas, its assembled scientists, although doubtless just as human as their California friends, have been able to avoid the pointed personalities that beset the meetings of the earnest souls at Smith's Corner. As a result, the State Academy of Science has pursued its tranquil and helpful way through seventy-five annual meetings.

Established in 1868, when the State of Kansas was but seven years old, the Kansas Academy of Science has grown from an original membership of seventeen to a group of over six hundred, including on its rolls nearly all the scientific workers in the colleges, laboratories and industries of the state. One of the oldest and largest of the state academies of science, we may be pardoned our pride if, on our 75th birthday, we enumerate some of our accomplishments. For seventy-five years we have kept alive and fostered studies of the mineral and agricultural products of the state and have made available in published form some fifteen hundred scientific studies; the development of the coal, the oil, the zinc and the lead industries were all initiated in whole or in part by the Academy of Science; the State Geological Survey, which in turn has played a prominent part in the State's development, was conceived and originated by the Kansas Academy of Science; and we have been active in the preservation and conservation of areas of natural beauty or of unusual interest. All these and other important activities of the Academy might be called to the attention of the public but the most important contribution of the Academy to the State is a less tangible one—the influence which it has exerted in the development of scientific training. Kansas long has had a notable reputation in producing and training scientific leaders and no little of this reputation is directly traceable to the activities of the State Academy of Science. To be more specific, let me give you the comment received from Dr. Edward R. Weidlein, Director of the Mellon Institute of Industrial Research, a comment whose substance I have heard repeated in variant form time and time again from many men who received their early training in Kansas. Dr.

Weidlein writes: "The Kansas Academy of Science has had a wonderful record during these years and has had as its members some of the outstanding scientists of the world. Its influence has been fine in encouraging the development of science. During my early scientific career, I was greatly stimulated by my contacts with the Academy."

These notable achievements of the Academy are due, of course, to the members of the Academy and to their leaders during its seventy-five years of existance. A roster of all these souls would include the names of the State's scientific great. Individuals, who not so well-known in their day as their better publicized contemporaries, the politicians, have nevertheless in their quiet and methodical way, contributed to the greatness of the state. Mudge, Snow, Fraser, Failyer, Bailey, Nichols, Sayre, Parker, Williston, Haworth, Knaus, Popenoe, Marvin, Lantz, Willard, Dains, Cady, to call a partial roll of past leaders of the Academy have, in a large measure, been responsible for the success achieved by the Academy. Although most of those named above have been gathered to their fathers long years ago, their influence still survives for they fashioned the pattern and set the standards for future, as well as past, conduct and development. The Academy and the State itself owes them much.

It is understandable with this record of past achievement and of notable leaders, even amidst the uncertainties, the strain and toil of the present day, that the decision was made to celebrate the diamond anniversary of the Academy with appropriate ceremonies at its 75th annual meeting. To be sure, in view of present day necessities, the program was compressed into a single day rather than the customary three-day meetings of recent years.

In addition to the shortened but regular specialized programs and the annual banquet, a special anniversary symposium by selected speakers was arranged by President Raymond H. Wheeler. The symposium, "Science and the War," was planned for the purpose of reviewing the part the various sciences were playing in our common effort to overcome the enemy, the chief objective of life at the present moment. Since the speakers in this group have presented their topics in less technical language than is their usual want, and since their discussions emphasize the amazing complexity of modern war, the Academy has seen fit to publish these papers for distribution to the general public as part of the celebration of its 75th anniversary. In making these papers public we have felt that we are fulfilling in part one of the two primary objects of the Academy as stated when it was organized in 1868, "To increase and diffuse knowledge in the various departments of science."

Admittedly the topics treated herein, although overlapping to some extent, are incompletely covered and, in fact, the contributions of several fields of science to the war effort have been unavoidably omitted. Part of this incompleteness is due to the fact that many of the contributions of science to the winning of the war will not be known, even to the members of the profession at large, until the war is over. Even with their incompleteness, however, a reading of these papers will convince anyone—if any conviction is necessary—that science and scientific workers have a major role to perform.

To those of us who are teachers of science and who may feel that our efforts are so indirect, there must come the encouragement from reading these pages, that our routine work of teaching must play and is playing a very real

part in the final result of victory. As the months roll by and the great climactic hour approaches, we can feel with confidence, as can thousands of other Americans working on the side lines, that our efforts have contributed an important share in making that hour realizable.. Within the past month, a letter from a friend, an officer with our armed forces in North Africa and one who has had good opportunity to observe science at war, contained the concluding words, "The part science is playing in the war is amazing and the work which you and your colleagues are doing in training personnel is just as important in beating those devils as the work of those of us overseas".

If science is so powerful a weapon in the art of war, it can likewise build a powerful bulwark for the preservation of peace; a use, we trust, to which we can shortly employ it as vigorously and as intensively as we do in waging war.

University of Kansas
Lawrence
August 10, 1943

Robert Taft
Editor, *Transactions of the Kansas Academy of Science*

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Food in the War Effort[1]

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The food problem is one about which there should be neither complacency nor hysteria. At the outbreak of the war, this country was too complacent regarding food. Agricultural production had been so abundant during the preceding twenty years and demand for food was so restricted because of low purchasing power at home and inability to export, that the American public had come to think of food only in terms of abundance and surpluses. The public also thought of this country as potentially self-sufficient in practically all essential agricultural needs. Few had realized the extent to which the country could be embarrassed by the cutting off of imported products.

Now that the difficulty of providing an ample supply of food is beginning to be appreciated, there is evidence of hysteria. There is no more justification for an hysterical attitude toward the food problem at this time than there was for the complacent attitude that existed at the outbreak of the war. American people will not go hungry. All food preferences may not be met but there will be an ample supply of wholesome food to feed the American people.

The food producing capacity of this country is tremendous. It is capable of meeting home needs without difficulty. The problem at this time, however, is one not only of meeting the needs of this country, but in addition, the problem of supplying large amounts of food for lend-lease purposes and building up a reserve for the post-war period when there probably will be several million hungry people in desperate need of food in those countries now occupied by the aggressor nations. It is to meet these needs that the American public is being asked to produce and conserve food at this time.

The extent to which food is desired to meet the need of the fighting front requirements for military and lend-lease purposes has been estimated by Secretary Wickard of the United States Department of Agriculture, to be the following percentages of the total estimated production of 1943:

Beef—20 to 25 per cent; virtually all of which is for American armed forces.
Pork—30 to 35 per cent.
Eggs—25 to 30 per cent.
Butter—15 to 20 per cent.
Cheese—40 to 45 per cent.
Condensed and evaporated milk—40 to 45 per cent.
Lard—25 to 30 per cent.
Edible fats and oils—20 to 25 per cent.
Canned fruits—50 to 60 per cent.
Dried fruits—35 to 45 per cent.
Canned vegetables—45 to 50 per cent.
Wheat—10 to 15 per cent.
Rice—15 to 20 per cent.

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[1]Contribution No. 76 from the Office of the Director, Agricultural Experiment Station, Manhattan.

THE FOOD GOALS FOR 1943

Food production in 1942 was the largest in the history of this country, but this record production is not enough to meet the demands for 1943. The need keeps growing. To meet the needs of 1943 will require substantial increases in many types of food products Food production goals have been suggested by the United States Department of Agriculture for the major agricultural products. These goals have been set after careful consideration has been given, first to need, and second to the ability of the country to produce. In few instances are the goals as high as the need would indicate, but they have been limited because it appeared that greater production could not be attained under existing conditions.

The agricultural products for which goals have been established may be grouped into the following general classes: (1) Meat, (2) oils and fats, (3) milk, (4) eggs and poultry, (5) fruits and vegetables, (6) feed grains and hay, and (7) wheat.

MEAT

The 1943 meat goals call for the production of nearly 26 billion pounds of beef, pork, veal, lamb, and mutton. This is 4 billion pounds more than was produced in 1942 and 50 per cent more than the average production for the period, 1936 to 1940. It is not expected that the slaughter of sheep and lambs will exceed that of last year and beef and veal production is expected to exceed the production of 1942 by only about 9 per cent. The large increase desired is in the production of hogs. The 1943 pig crop should total 120 million head as compared with about 105 million raised last year. The requested slaughter of 100 million hogs this year with a 10-pound increase of average weight above that of last year, would result in the production of nearly 14 billion pounds of pork. Pork is needed not only for meat purposes but it constitutes the most important animal source of fat and oil.

OILS AND FATS

During normal times, depending upon the purchasing power of this country, the United States used between 8 and 10 billion pounds of fats and oils. Of this amount, from 1½ to 2 billion pounds were normally imported annually. Except for oil to meet special needs, the entire normal requirement of the country could be met without much difficulty. The domestic need at present, however, exceeds greatly the normal supply and in addition is that needed for lend-lease purposes. It is only possible for this country to meet these increased demands by exerting the utmost effort in each of two ways: (1) Through increased production of animal fats and (2) through increased production of vegetable oils.

Roughly, two-thirds of the increase of oils and fats that are needed should be met by increasing the production of animal fats, chiefly through increased hog production with some increase in dairy and beef cattle production. It should be remembered that the original source of animal fat is crops. The increase in livestock production that is desired means a corresponding increase in the production of grain crops. Thus, corn, sorghums, barley, and other grains become vital war crops.

The vegetable oils that it is possible to produce domestically are corn oil,

cottonseed oil, linseed oil, castor oil, olive oil, soybean oil, peanut oil, and tung oil. The opportunities to increase corn oil and olive oil are limited. Linseed oil, castor oil, and tung oil, while important war products, are not edible oils. No marked increase in cottonseed oil should be expected since an increased supply of cotton fiber is not needed. The two crops to be depended upon to supply an increase in edible oils are soybeans and peanuts.

The soybean goal for 1943 is 10½ million acres and the production of 189 million bushels of beans at a normal yield of 18 bushels a harvested acre. After taking out seed and feed, about 163 million bushels may be left for crushing to produce around 1,440 million pounds of oil. The acreage goal established this year for soybeans is slightly below that harvested in 1942 because of limited crushing facilities which made difficulty in processing the crop produced last year.

A goal of 5½ million acres of peanuts has been established for 1943. This is 49 per cent more than were picked and threshed in 1942. A normal production from the acreage suggested for 1943 would be 3,712 million pounds. Of this amount, at least 1,450 million pounds will be needed for seed, edible trade, and local uses, leaving at best 2,200 million pounds for crushing. Peanuts are produced chiefly through the southern states. To reach the suggested goal it will be necessary to substitute peanuts for other crops, especially short staple cotton, and to increase the acreage in some of the newer production areas, especially in Texas and Oklahoma.

MILK

The goal established for milk production in 1943 is 122 billion pounds, which is 2 per cent more than was produced in 1942. The total demand for milk and dairy products is expected to equal as much as 140 billion pounds, but a production of 122 billion pounds is as much as dairymen can expect to reach in view of the labor shortage and other factors. It is to be expected that as the need for whole milk increases, less of the product will be used for butter and cheese, leaving more to be utilized as whole milk.

EGGS AND POULTRY

Heavy military and lend-lease demands for dried eggs will leave fewer eggs for civilian consumption in 1943 than civilians will wish to buy in view of meat rationing. The goal for egg production is 4,780 million dozen, which is 8 per cent above the record egg production for 1942. The goal for chickens for meat is 4 billion pounds, or 28 per cent above the large production last year. To meet this goal will require an increase of 10 per cent in the number of chickens raised for flock replacement on farms, a production of at least 100 million young chickens for meat on farms outside the usual production season, and an increase of 75 million birds weighing at least 3 pounds by commercial poultry producers. This is an ambitious program in view of the large production last year, but is necessary if consumers are to supplement rationed meats with poultry to the extent that is anticipated.

FRUITS AND VEGETABLES

There is urgent need for a maximum production of all vegetables and fruits. The commercial production for canning and drying will be needed so completely to supply military and lend-lease purposes that civilians will be

required to depend much more extensively than this past year upon the production from victory gardens and upon home processing. The goals for 1943 call for slightly more than 25 million bags of dried edible beans, more than 6 million bags of dry peas, 3,260,000 acres of Irish potatoes, which is 17 per cent more than the acreage last year, a commercial truck crop for the fresh market of 1,720,000 acres, a total pack of canned vegetables equal to the production in 1942, and a production of the eleven major fruits equivalent to nearly 15 million tons fresh basis. This heavy production will fall far short of meeting consumer demand unless a major portion of this demand is met from the production of victory gardens and home processing. The rationing of canned fruits and vegetables will encourage victory garden planting and home processing this year. The goal of 18 million victory gardens should be reached.

FEED GRAINS AND HAY

Because of the need for increased livestock production, an ample supply of feed grains and hay is important. Increased production of corn is being encouraged not only within the commercial corn producing area but elsewhere throughout the country where corn may be grown successfully. Increased barley and grain sorghum production is also being encouraged as well as the production of hay and other coarse livestock feeds. An increased production of peanuts and flax with a continued heavy production of soybeans will help to meet the need for high protein concentrate feeds of which there has been a shortage this past year.

WHEAT

This is the first war experienced by this country during which wheat was not considered a war crop of major importance. This is not in any way due to wheat being a less important food than in the past, but to the large supply of wheat on hand at the beginning of the war and to the heavy production of wheat in the United States and Canada last year. The large supply of wheat on hand and the difficulty of finding storage space for it should not result in a too complacent attitude with regard to wheat. Wheat has many uses. It is so valuable for human food that it is seldom considered for other purposes. It can, however, replace successfully most other grains for livestock feeding. It has many industrial uses. The large supply of wheat now on hand is a highly valuable asset and constitutes one of the major food safeguards of the country. Wheat can be produced with a minimum of labor. Its production should be maintained at as high a level as is consistent with good farm management practices and the production of other essential agricultural products.

FACTORS TENDING TO LIMIT MAXIMUM FOOD PRODUCTION

The need for maximum food production is fully recognized by farmers. Every effort will be made to attain the production goals that have been suggested. If the goals are not reached it will be not from lack of the desire and intention to do so, but to factors limiting production largely beyond the control of the farmer. Some of these factors are:

The Weather.—The weather last year from the standpoint of general food production was the most favorable in many years. It is doubtful if two years equally favorable will occur in succession.

Labor.—Farm labor is nearly impossible to obtain. Labor has been lost from the farm to both the armed forces and industries designated as essential defense industries. Agriculture, because of the importance of food, should have been designated as a defense industry before labor was drained from farms so extensively. Steps are now being taken to alleviate the farm labor situation, but it is doubtful if these steps have been taken in time to supply the labor needed to meet the production goals that have been suggested for this year.

Machinery.—Farm machinery is rationed. Very little new machinery is obtainable. While steps are now being taken to increase the supply of new machinery over that supplied last year, the amount available will still be below that needed for maximum production.

Other Retarding Factors.—Other factors tending to retard maximum food production are: Restrictions placed upon transportation; inability to supply the amount of fertilizer needed, especially nitrogenous fertilizers; and a shortage of high-protein feeds needed for maximum milk, egg, pork, and beef production. All of these factors, lack of labor, machinery, transportation, fertilizers and feed, will increase the difficulty that will be experienced in producing the food that will be needed for 1943. But the American farmer is resourceful. He is accustomed to long hours and to hard work and in spite of these handicaps, given reasonably favorable weather, the production from the farms of the country this year should be large.

Relation of Physics to the War Effort

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Even before our entry into the war, when we were still in that era known as the defense era, physicists were paid a very flattering compliment. It was truly an inspiring compliment and one which did much to bolster the physicists' morale throughout the war. The statement from which this compliment was derived originated in England and dealt with the relative merits of physicists in war time. It was an opinion, stating that "a hundred physicists are worth a million soldiers." This ratio, one hundred to one million, is almost incomprehensible and suggests the amusing picture of one million smartly dressed, orderly arrayed soldiers occupying one pan of a huge set of scales while on the other scattered about are one hundred absent-minded, stoop-shouldered, student-ridden professors of physics It is indeed difficult to see how a pair of scales loaded in this manner could ever balance. If one were, however, to add to these scales even a small fraction of all the equipment and apparatus developed by these one hundred physicists, all grounds for skepticism regarding the state of balance must certainly vanish.

The fact that physics plays an important role in our war is obvious from the very nature of the weapons that are now being used. For example, the instrument panel of an airliner contains forty instruments, all of which are applications of physical principles. Almost every signaling device furnishes good illustrations of physical laws in operation. In the maintenance of production we might mention the electron microscope as just one out of literally thousands of pieces of apparatus which have been developed by physicists and which help produce war materials. So intimate is the relationship between physics and the present war that the war has been entitled the "physicist's war," this, by no less a person than Chemist James B. Cônnant, chairman of the National Defense Research Committee.

Physicists contribute to the war effort mainly through two channels, that of research or development, and that of instruction. Regarding research, a systematic program was initiated at a very early date and was in operation by the time Germany invaded Belgium and Holland, fully a year and a half before our formal entrance into the war. At the time of Pearl Harbor, research physicists were almost completely mobilized. There were at that time nearly two hundred physicists directing teams of investigators on specific war problems. The teams themselves were composed of about fiive hundred professional physicists. Most of these seven hundred from the profession were loaned from university teaching staffs and were men of considerable research experience. They represented about seventy-three per cent of all the physicists in our country who were at the time judged both capable and free to carry on this type of work. Although this group has been increased considerably since our entrance into the war, it is not possible now to ascertain the exact number of men involved. This program of research is being carried out under the

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N.D.R.C. in small groups scattered over the country. They are housed for the most part in colleges and universities. The best known of these has a staff of several hundred and operates under the name of Radiation Laboratory and is located in Cambridge, Massachusetts.

These physicists may be regarded as occupying the front line in the physicists' war. Unfortunately for us it is a battle front that issues no communiques and its work and accomplishments must remain a secret.

In spite of this necessary secrecy one can make a guess at the nature of some of their problems. For example, one can deduce that since one of the laboratories is called Radiation Laboratory, and since one of the investigators there has published a book on micro waves, at least some of the research at that place is on the detection of airplanes by means of micro waves. When one learns that a good X-ray physicist moves his laboratory from the physics building to the metallurgy building, one supposes that his problem is one related to the improvement of armament and alloys. Papers delivered at scientific meetings entitled "The Equations for Falling Bodies in a Resisting Medium" suggest equations for the descent of parachutes. Hearing a theoretical physicist who has never read a paper on anything less esoteric than the extra-nuclear fields of an atom, deliver a paper on statistics and turbulent flow suggests anything from the theory of airflow around projectiles and airplanes to turbulence in feed pipes of an airplane motor. One is also led to surmise that because the cyclotron laboratories of our country are under close guard something with the atomic nucleus is also being worked upon. And when we read in the newspaper that an American battleship sails into an unlighted sea and opens fire at a silent, invisible enemy ship, one infers that some physicist has been using some unusual part of the electromagnetic spectrum to very good advantage.

Although we might not know the details of this research program, we have an indication of its importance from the record of a similar body of men in England. In England's darkest hour, September, 1940, when she had only three hundred first-line Spitfires and Hurricanes to fight off the Luftwaffe, a device due to physicists was incorporated which stepped up the power of British planes twenty times, and one hundred eighty-five of the Luftwaffe were shot down in one day. At about the same time another device was developed which in one stroke erased the menace of the German magnetic mine. These contributions easily explain the inspiration of Lord Beaverbrook's enthusiastic remarks, "It is the scientist who will protect us against the loss of our lifeblood. It is the scientist who will save our home and guard our hearthstones."

Just as it is not possible at present to tell what our research physicists have accomplished, it is also impossible to state what might have been done had there been as many physicists available as were needed. Both in governmental research laboratories and in industry there has been an acute shortage of professional physicists. The demand exceeds the supply by a factor ranging from seven to ten. The number of physicists trained each year is measured in hundreds; the number needed is measured in thousands. This need brings us to the second of the war-time tasks, namely, that of teaching physics.

The program for the instruction of war-time physicists does not seem to have been as well organized as that for carrying out war-time research. It is true that much was said about increasing the teacher's output, that is, increas-

ing the number of graduates in physics, but relatively little seems to have been accomplished. The physics teacher's principal task has been and still is that of turning out B.S., M.S., and Ph.D. physicists. He often finds, however, that now most of his energy is being utilized in another important job, that of teaching elementary physics to students in other fields such as engineering and medicine. With the coming of sailors and soldiers to the campus, the teaching of the elementary course in physics has become even more of a strain. There is a real danger that the civilian student group from whom we must raise a sizeable crop of professional physicists will be sorely neglected.

The present figure for the rate at which physics teachers turn out their products is about four hundred Ph.D. or M.S. physicists per year. Again this production is far smaller than the demand. This year, industry and governmental research want four thousand physicists, which is just ten times the normal output. There seems to be no hope that this figure will be reached. In fact, only seven hundred physicists are expected to get degrees in the graduate schools this year.

Regarding the teaching of elementary physics, records show that 90,000 students were enrolled in beginning physics classes a year ago. The new plan now getting under way calls for the teaching of elementary physics to 250,000 men, almost a three-fold increase. It has been estimated that all physics faculties will be ultimately increased to twice their normal size. This increase is being largely accomplished by the use of what have been called "ersatz" teachers. It is expected that, on the average, physics faculties will be diluted to the extent that they will be composed of three parts old-line teachers and two parts ersatz.

From the figures I have stated, it is quite apparent that we have a serious shortage of physicists. Almost overnight, physicists have been promoted from semi-obscurity to membership in that select group of rarities which include rubber, sugar and coffee. Our country has discovered that to wage modern war requires more physicists than we ordinarily carry in stock. An inventory of our peace-time supply shows only one physicist for every 30,000 individuals. For adequate military protection and for the maintenance of a war-time industry this ratio is far too low. In these days any nation which does not impregnate a sizeable fraction of the student body of that nation with sufficient physics and mathematics, runs danger of becoming a weak sister among nations and of being preyed upon by those with a firmer scientific foundation. A modern nation, if it is to survive, must promote and encourage through its educational system a healthy growth of physics.

There are many causes for this dangerously low population-density of physicists. One of them is the lack of training given high school teachers of physics. This lack of training has lowered teaching standards in the field as a whole and has resulted in fewer high school students being interested in physics as a career. From 1910 to 1939 there was in our high schools a three-fold drop in percentage enrollment in physics. Surveys show that in some states less than forty-four per cent of high school teachers have had the equivalent of a college course in physics and some have had no training in physics whatsoever. It is generally believed among professional physicists that this state of under-training could be removed if, in the training of high school teachers, emphasis were shifted from professional education courses to courses in the subject matter taught. In a recent physics journal the editor, referring

to the present shortage of physics man-power writes "The causes of this lamentable situation are deeply rooted in the current trends of educational philosophy." Perhaps one of the unforeseen benefits of our war will be that of a change in our educational philosophy. We sincerely hope that the war will have forced upon us a higher ratio of subject-matter courses to professional educational courses in the college curriculum of our high school teachers.

It is the physicist's wish that his subject shall not only serve our country well during this war but that it shall also serve in the peace which will follow. There is, as A. H. Compton points out, some similarity between physics and a certain legendary sword. According to the story, Daedalus, with his newly invented forge, fashioned a steel sword which he presented to King Minos. King Minos, as the story goes, objected, saying, "This sword will bring us not happiness but strife." Daedalus then replied, "'Tis not my purpose to make you happy but to make you great." And that is our hope, that physics shall make our country great in peace as well as in war.

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Bacteriology, Medicine, and the War

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The function of medicine and its numerous handmaidens, such as bacteriology, in our armed forces is primarily the reduction of casualties or impairment of physical fitness due to any of several factors.

It is a medical board of examiners that determines the physical soundness of the entire personnel of the armed forces before induction and it is the medical corps of the various branches that attempts to keep the men physically fit for active service.

The factors responsible for lowering the physical fitness and for producing illness or death in any military force may be summarized in part as follows:

1. Malnutrition
2. Psychological maladjustment and mental breakdown
3. Climatic factors including desert heat and sand and winter cold
4. Chemical and thermal casualties
5. Traumatic injuries
6. Infection and inadequate sanitation

In the Revolutionary War and the War of 1812, and in the Mexican, Civil and Spanish-American Wars malnutrition was present, but was largely overcome in World War I and II. It is quite comforting to believe that the American army is the best fed army in the world. In regard to mental shock and psychological breakdown, we are trying to profit by the experience of World War I. The high incidence of these casualties, probably exceeding 25 per 1000, among our armed forces that has developed since we entered the war suggests that physical examination and classification should be supplemented by psychological examination and classification. The problem has been put into the hands of a trained personnel and we hope for better results in the future.

When we consider climatic and related factors, it is possible that the enemy has suffered more than the Allies. The Germans must have encountered heavy casualties from freezing, frostbite, and other complications during the winter campaigns in Russia. Both the Axis and British troops have had to endure the rigors of a long desert campaign that was extremely hard on both man and materiel. The sharp cutting sand injured the skin and eyes of troops and reduced the life of motors by perhaps seventy-five per cent. While the American troops have, to date, escaped these hazards, they have had many casualties due to ice and fogs in the Aleutians and to the jungle heat of Guadalcanal.

Casualties from chemicals such as poison gas were peculiar to World War I. Up to the present there is very little available evidence that poison gas has been employed by either side in World War II. The Germans know that the Allies are extremely well prepared to cope with this type of warfare should it be introduced by them.

In regard to traumatic injuries leading to hemorrhage, shock, and infection, it is quite likely that, due to the increased fire power and type of warfare being waged at present, the incidence of traumatic injuries will increase among

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both civilians and troops, but there are several reasons why the percentage of complications should decrease. In the first place, an improved method of handling serious fractures has been perfected.

Transfusion was unknown or not in use prior to World War I. The blood groups had only been discovered a little over a dozen years preceding 1914. Blood banks and stored plasma are innovations of World War II. These are now known to be very effective weapons in the hands of the Medical Corps and are being used quite successfully in the treatment of shock due to hemorrhage, trauma, or extensive burns. In our wars prior to World War I, tetanus antitoxin and any form of vaccination except perhaps smallpox was unknown and sanitation was almost non-existent..

From the standpoint of infection one has to consider:

1. Skin infections
2. Wound infections
3. Gastrointestinal, respiratory, and contagious diseases
4. Insect borne infections
5. Venereal diseases

The most prevalent type of infection among our troops is one of the skin (Athlete's foot) caused by certain fungi. It is estimated that from sixty to seventy-five per cent of the men are infected. This is being vigorously controlled by local treatment since sound feet are very essential to the effectivness of a soldier.

In all previous wars we have been more or less helpless in handling wound infections. Against the hemolytic streptococcus and the anerobic spore formers causing gas gangrene and tetanus, we had only two weapons, the surgical removal of devitalized tissue and the use of tetanus antitoxin that became available only in World War I. The use of chlorine in the form of Dakin's solution was not possible until late in World War I. Sulfa drugs are a very recent innovation. Today every soldier in the field is supplied with them to apply locally or to take by mouth if wounded. It is now well established that sulphanilamide and related compounds are very effective against the pneumococcus, hemolytic streptococcus, and perhaps against *clostridium welchii,* the principal cause of gas gangrene. All of our troops, on entering the service, are immunized against the toxin causing lockjaw, and when wounded, are given tetanus antitoxin. While the value of the tetanus antitoxin is established, the prophylactic or therapeutic value of the "gas gangrene" antitoxins is still a matter of dispute. The combination of surgical removal of devitalized tissue with adequate treatment with sulfa drugs is proving very effective in reducing the mortality from infection following traumatic injury. Never before in our history have troops been so protected as during the present war.

The gastrointestinal diseases, typhoid fever, the dysenteries, and Asiatic cholera, have resulted in a very high mortality in all of our wars prior to World War I. One out of every five soldiers in the Spanish-American War had typhoid. Vaccination against typhoid was introduced into our army in 1911. The typhoid vaccines of 1943 are superior to those of 1911. We have learned that the best vaccine must be prepared from strains that have a high immunizing power, and that they must be so handled as not to impair their immunizing quality. Our immunization program also includes, for the first time in our history, vaccination against Asiatic cholera. The army vaccine

consists of a suspension of cholera vibrios numbering eight billion per cc. Two doses, seven to ten days apart, are given. The first of 0.5 cc. and the second of 1.0 cc. are given subcutaneously. Up to the present no satisfactory methods have been devised to protect against amebic and bacillary dysentery although antitoxin for the toxins of shigella have been produced. Of equal or greater importance than immunization is sanitation and insect control. Until World War I little attention was paid to the sanitary care of the food and water consumed by the troops. Now all soldiers in the field have hypochlorite to sterilize water to drink, and the troops are supplied with Lister bags holding thirty-five gallons of water into which is put hypochlorite that sterilizes it within thirty minutes. Thus, by immunization, sanitary measures and education, gastrointestinal infection is controlled to a large extent.

As in all previous wars, respiratory disease such as lobar pneumonia and the secondary pneumonias of measles and influenza will result in casualties. There is no well established successful method of immunization against the organisms causing these diseases. The results of preliminary studies of the influenzae virus vaccines have been unsatisfactory. Whether the pneumococcus type I polysaccharide vaccine will prove worthwhile remains to be seen. Likewise, there is no known method of successfully vaccinating against the meningococcus that causes meningitis although specific antisera have been used therapeutically for many years. Fortunately, however, the sulfa drugs are proving more or less effective against both the pneumococcus and the meningococcus. Unfortunately the sulfa drugs are not very effective against the virus of measles or influenzae, nor against organisms such as Pfeiffer's bacillus and alpha and alpha prime streptococci which may cause complications of pneumonia or meningitis.

Among the insect borne diseases the most widely encountered is malaria which has decimated armies since the memory of man. In the Revolutionary War, Civil War, and in Guadalcanal, the Philippines and Africa during the present war, malaria has been a serious threat to our armies. Unfortunately, there is no known method of immunization against the causative agents. The two methods of prevention are mosquito control and chemotherapy. The latter consists of three drugs—plasmochin, atabrine, and quinine. According to Reed (1940), the greatest value of plasmochin is in destroying the gametocytes or sex forms of tertian and especially subtertian malaria. It exerts unequal action on the plasmodia. Atabrine is effective against schizonts of *plasmodium falciparum* in malignant subtertian malaria. Quinine is largely ineffective against the gametes of this species in malignant malaria. All three drugs have their place in the treatment of malaria, but it is evident that there is great need for a more effective method of therapy. For three other insect borne diseases, yellow fever, typhus fever, and plague, vaccination is being employed along with attempts to eradicate the insect vector.

Yellow fever is a virus disease transmitted by mosquitoes. The vaccine is a living one prepared from tissue cultures (chick embryo) to which human serum was added until recently. The vaccine is kept frozen until used. An attenuated virus called 17D has been used quite extensively and is now known to be quite safe and effective without serum. It is thought that the serum used in some batches of vaccine was responsible for a contaminating virus or other agent causing a serious disease associated with jaundice.

Typhus fever is a disease caused by a rickettsia, transmitted as a rule by the body louse. The vaccine is one devised by Cox and consists of a killed yolk sac culture of the organisms. Typhus fever was a serious problem in World War I and must be reckoned with in this war. The Germans have encountered it in Poland and along the Russian front. For the first time in history, partially effective vaccines for the virus of yellow fever and the rickettsia of typhus fever are available for mass immunization.

The plague vaccine which the army is using consists of a suspension of two billion killed plague baccilli per cubic centimeter. An initial subcutaneous injection of 0.5 cc. is followed seven to ten days later by a second injection of 1.0 cc. This latter dose may be repeated every four to six months. Recent work suggests that a better plague vaccine than that now employed may be possible. In Java, L. Otten vaccinated 2,500,000 people with a live, avirulent variant of the plague strain "Tjiwidej". While early reports are favorable, it remains to be seen whether the vaccine is desirable. The War Department emphasizes the fact that vaccination alone is not adequate for the prevention of these diseases. The resulting immunity is not complete and is of short duration. Therefore, other control measures are imperative.

Lastly, there is the problem of venereal disease and the war. While there are five recognized venereal diseases, time will permit for a brief mention of only two of them, syphilis and gonorrhea. Before we entered the war, a survey made by Gordon, indicated an incidence of syphilis of 0.78 per 1000 and of gonorrhea, 2.84 per 1000 troops. It is estimated that since entering the war the incidence of gonorrhea has increased to somewhere between 16 and 25 per 1000. This is much less than during World War I when gonorrhea was probably three or four times as great. There is good reason to believe that gonorrhea will be materially reduced since the sulfa drugs seem to be of both prophylactic as well as therapeutic value. It should be remembered that the source of veneral disease in our armed forces is the reservoir of veneral among prostitutes. Here at home, state and municipal health departments can cooperate with the army and navy in their campaign to eradicate venereal disease by cleaning up the source of infection. Every citizen should be actively interested in seeing that such a goal is achieved.

In conclusion, I can recapitulate a few of the points brought out as follows: In 1918, one could say that in all of our wars prior to World War I the following were either unknown or unavailable: X-ray, transfusion, tetanus antitoxin, the arsenicals for the treatment of syphilis, typhoid vaccine, and adequate sanitation. These marked the advances in medicine available in World War I over those existing at the time of the Spanish-American War of 1898.

In 1943, we can say that in addition to the advances available to the medical corps of 1914-18, there can now be listed as subsequent medical weapons and procedures the following: the perfection of improved methods of handling compound fractures; the introduction of blood banks and stored plasma to control shock and hemorrhage; of sulfa drugs to control infection by the hemolytic streptococcus, pneumococcus, gonococcus, meningococcus, and to a certain extent the staphylococcus; the introduction of active immunization against tetanus, yellow fever, typhoid fever, cholera, plague, and lastly the application of definitely improved sanitary measures.

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Chemistry in the War Effort

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The only real criterion of the importance of a physical science in the war effort is the material contribution which that science makes. Chemistry, through the development of the chemical industry, is playing a major part in producing vast quantities of essential items. The American chemical industry in its present state had its origin in the last war. Previous to 1914, we were largely dependent on Europe for our chemicals. In the past twenty-five years, we have progressed from an importing to an exporting nation with chemical exports valued at $300,000,000 per year.

This situation has made the development of a war industry easier, but it must be remembered that our civilian economy had adapted itself to this greatly expanded chemical production. This adaptation is well illustrated by the civilian and military demands for such items as nylon and alcohol.

A tremendous variety of chemicals is required for war time use. The heavy chemicals, such as sulfuric acid, ammonia and nitric acid, chlorine and caustic soda, are being turned out in greatly increased quantities. It is estimated that the annual production of chlorine may now be one million tons. These chemicals are used in the manufacture of explosives, synthetic rubber, military gases, plastics, synthetic organic chemicals, fertilizers, solvents, rayon, paper, aluminum, magnesium, glass, petroleum products, and a host of other essential materials.

The manufacture of military explosives is a chemical industry which has undergone one of the greatest expansions. In 1939, there were only several small plants, while today this is one of the largest branches of the entire chemical industry. Approximately ten thousand trained chemists and chemical engineers are needed to operate the plants producing explosives and the essential raw materials for these exlosives plants. The magnitude of this enterprise may be appreciated when it is realized that the daily requirements are six million pounds of nitric acid, ten million pounds of sulfuric acid and two million pounds of ether and alcohol. The principal products of the explosives plants are smokeless powder and TNT. Smokeless powder is a misnomer, for the material is neither smokeless nor a powder. This propellent is manufactured from cotton linters and wood cellulose. After nitration, the product is carefully purified to reduce the free acid content to less than one one-thousandth of a per cent. This extreme purity is characteristic of the care employed in the manufacture of explosives. Research on new processes of recovery of acids and solvents have reduced the requirements for smokeless powder, but they are still stupendous.

TNT and mixtures of TNT and ammonium nitrate called Amatol are the principal bursting charges of all high explosive shells and bombs. The weight of high explosive required to fill a bomb is approximately 50 per cent of the loaded weight. In a three thousand ton raid, three million pounds of high

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explosives would be dropped. Two-thirds of the TNT manufactured in this country is made from toluene which has been prepared from petroleum. About three years ago this process was in the laboratory stage, untried in industry. Now thousands of gallons a day of toluene pour out of our petroleum refineries to supplement the smaller quantities which are obtainable from coal tar. Without this new process or a similar one, it would be impossible for us to supply the toluene required for the manufacture of TNT. Since 1918 great progress has been made in the manufacture of ammonia and nitric acid from natural gas and air. The processes in use during the last war could not, by any stretch of the imagination, keep up with the present day requirements.

Several other explosives are used in minor quantities. Tetryl, trinitrophenyl methyl nitramine, is used as a booster charge to facilitate the detonation of TNT which is not sensitive enough to be set off by means of a small detonator. Tetryl, an extremely powerful explosive, is too sensitive to be used for the entire bursting charge so a lesser quantity is used as an intermediate explosive between the detonator and the main bursting charge. The initiators, the explosives set off by the action of the firing pin in the fuze of a bomb or high explosive shell, have been greatly improved since the last war. Azides have to a great extent replaced the fulminates which were formerly used. This replacement has resulted in a great decrease in the number of duds, because of the more positive action of the azides.

The materials normally classed as chemical warfare agents include incendiaries, gases, flame throwers, smokes, and protective equipment. Of these the incendiary bombs are probably being used to the greatest extent at present. The production of magnesium and thermite for the old standard bombs has developed into an industry of great extent. Millions of two-pound bombs require thousands of tons of materials.

To date there has been practically no employment of gas in this war, but the situation may change in the near future. The chemicals which are designated in warfare as gases are mostly heavy liquids. Some of them are solids. Mustard gas, which is perhaps the principal agent, boils at a temperature of approximately 180° C. This agent is extremely effective. Only 0.02 of a milligram will produce a blister on the skin A small fraction of a gram diffusing through the shoes or clothing will make a hospital casualty out of any person in a contaminated area who is not properly protected. It is estimated that it would require at least six weeks to decontaminate a city which had been subjected to a single raid in which 200 tons of mustard were sprayed from planes. Lewisite, a development of our own country, has not only all of the vesicant action of mustard but also produces systemic arsenic poisoning. General Waitt recently announced a new class of gas which he termed "nitrogen mustards". They are said to be fatal in concentrations below that which can be detected by the olefactory nerves. Being of the "mustard type", they are also vesicants. These new gases are probably a great deal more effective than any which were used in the last war. The protective equipment which has been developed by American chemists is rated as the best in the world.

The synthetic rubber section of the chemical program has attracted more attention in the press than any other branch of the industry. This publicity

arises because practically every individual in the country is vitally affected by any serious restrictions on the civilian supply of rubber. In addition, various groups with political axes to grind have used the rubber shortage as a means of pushing their own particular schemes. Many difficulties have been encountered in carrying out the rubber program, some of which are technical and many political. There are few experienced men in the country who are available for work in synthetic rubber. The Goodrich Rubber Company and the Phillips Petroleum Company had manufactured synthetic rubber tires from petroleum butadiene for several years, but the butadiene supply was relatively small. Their butadiene was a byproduct of thermal cracking. Research had to be conducted not only on the processes for the manufacture of butadiene but also on the milling of the synthetic rubber, which has entirely different working characteristics than the natural product. There has been considerable discussion as to the relative merit of agricultural products and petroleum as sources of butadiene. The relative costs of the raw materials give a fair criterion as to the ability of the different processes to successfully compete. With butane priced at $0.06 per gallon the cost of raw materials per pound of butadiene is approximately $0.01. Grain selling at $0.85 per bushel would cost $0.08½ per pound of butadiene made by the alcohol process. Butadiene can be produced from petroleum at a total cost not exceeding $0.10 per pound whereas the total cost of production from grain would be from $0.15 to $0.20 per pound. The economic picture does not favor the production of synthetic rubber from grain. In any post war competition, the alcohol process must be based on the cost of alcohol from black strap molasses. Grain would have to sell at $0.20 per bushel in order to compete with molasses at $0.07 per gallon. The prewar price of molasses was $0.05 to $0.06 per gallon. On the basis of these figures, without taking into consideration any food or alcohol requirements, the production of the major portion of our synthetic rubber from petroleum is undoubtedly justified.

Plastics, which are highly polymerized or condensed compounds, are being utilized to an ever increasing extent as substitutes for some of the lighter metals as well as for purposes for which only these specific substances will serve. Plastics are made from a wide variety of raw materials such as cellulose, coal tar derivatives, vegetable proteins, natural gas and casein. These range in price from about $0.45 a pound for cellulose base materials to $2.25 a pound for methacrylate resins. The present production amounts to more than 300,000,000 pounds per year. About 250,000,000 pounds of plastics are made from coal tar. Bakelite and similar phenolic-formaldehyde resins comprise the major portion of resins of this type. Over 50,000,000 pounds are made from cellulose acetate, butyrate and nitrate, and ethyl cellulose. These cellulose plastics are made from cotton linters and to an increasingly greater extent from cellulose manufactured from wood pulp. Approximately 10,000,000 pounds of methacrylate polyvinyl resins are made annually from natural gas and other petroleum hydrocarbons.

The uses to which plastics are put are more varied than the raw materials from which they are manufactured. Ethyl cellulose plastics are replacing rubber for insulation on high tension cables. They are more resistant to oils and high temperatures than rubber, so that it is probable that rubber will not

be used for this purpose in the future. Polyvinyl resins from natural gas are used to cement the layers of safety glass. With proper plasticizers, some of the polyvinyl plastics make a satisfactory substitute for synthetic rubber for certain purposes where great elasticity is not required. Methacrylate resins are employed in the manufacture of plane and tank windows. The greatly increased production of bakelite, which is being used as a metal substitute in fuze parts and for thousands of other small units where great strength is not required, has created a shortage of formaldehyde and methanol.

The chemical industry is making a great contribution to the production of foods by supplying fertilizers which are vital to agriculture. In 1942, the quantity of fertilizer produced was the greatest in history, although the demand tended to exceed even this record production. The fertilizer situation is entirely different from what it was in the last war when we were struggling with a relatively new industry. More chemicals are used in the production of fertilizers than for any other class of materials. The supply of potash is now ample for any needs which may arise. This abundance is due almost entirely to the enterprise and ingenuity of the technical men in a single company which is our major producer of potash. A shortage of nitrogen fertilizer may develop but the production of fixed nitrogen is many times that of any previous period. The overall picture of the fertilizer industry indicates that the essential chemicals will be available although they may be not sufficient to meet the greatest demand in history.

The development of synthetic organic chemicals is without doubt the outstanding contribution of the chemical industry. Aviation gasoline, as now manufactured, consists largely of relatively pure hydrocarbons such as iso-octane and neohexane. These materials were laboratory curiosities several years ago. Now they are being produced at a rate which probably exceeds four billion gallons per year as a result of research which has developed practical methods for their manufacture. This synthetic fuel has been responsible for the major developments in airplane engines in the United States. The use of these super fuels is a decided military advantage because planes can be designed to fly either faster or farther when using these hydrocarbons as the source of energy for their motive power. Hundreds of millions of pounds of tetraethyl-lead are being produced annually to raise the octane rating of military motor fuels and are increasing the great advantage which we already hold in this field.

The synthetic rubber industry with an annual production of some 800,000 tons per year will require 200,000 tons of relatively pure styrene and 160,000 tons of plasticizers, such as butyl phthalate, in order that the synthetic rubbers may be manufactured into usable articles. Synthetic camphor is one of the more recent instances in which a synthetic material has completely displaced the natural product. In 1941, the imports of natural camphor reached the all time low of 5 pounds. It is interesting to note that in no instance has a natural product ever been able to compete with a synthetic material of identical constitution.

The coal tar industry is operating at peak capacity, producing phenol for plastics and other aromatic materials for dyes, intermediates and explosives. A large tonnage of compounds closely related to the dyes are used for blending

with smokeless powder, in which they act as preservatives and stabilizers.

Solvents are widely used as lacquer thinners and for the extraction of fats and similar materials. The demand for these solvents could never have been met if petroleum chemists had not developed cheap simple processes for the manufacture of acetone and similar ketones. The old wood distillation processes have insufficient capacity to produce even a small fraction of the solvents which are now required. Every bomb, every shell, every grenade that is manufactured is painted with at least one coat of rapid drying lacquer. Every piece of metallic equipment must be painted and repainted in order to protect it from the weather. Methanol is another solvent which is being produced in tremendous quantities. Part of this methanol product goes into oxidation processes in which formaldehyde is made. Many new heavy alcohols are now available which are excellent solvents and some of which are used as plasticizers. The chemical industry is now producing quantities of ethyl alcohol which were not thought possible a few years ago. Most of this alcohol is required for the production of smokeless powder, some for synthetic rubber.

The production of the light metals, aluminum and magnesium, have not required the same degree of research that has been necessary for the development of the synthetic rubber industry, but a number of interesting developments have been carried out. The production of aluminum is probably approaching a rate of 3 billion pounds per year, which is ten times the 1939 production. 600 million pounds of magnesium will perhaps be produced annually. This is a hundred times the 1937 production. These vast quantities of light metals are used principally on airplane parts with a large fraction of the magnesium going into the production of incendiary bombs. The electrolytic processes which were used for magnesium and aluminum have been expanded to provide plant capacity for the major portions of this output. New processes for the reduction of magnesium oxide have been worked out. These involve the distillation and subsequent condensation of the magnesium at pressures of approximately 0.3 of a mm, which is an extremely low pressure for the operation of any large-sized equipment.

The pulp and paper industry is becoming of increasing importance in the war effort. Paper impregnated with synthetic resins are used in the manufacture of moisture and grease proof containers which previously were made entirely of metal. In many other cases impregnated paper products are being used as metal substitutes. A large proportion of the cellulose which is used in plastics and smokeless powder is now manufactured from wood pulp. This branch of the chemical industry is thus supplying raw materials for several of the most vital sections of the chemical program and is aiding in the conservtion of metals to a very great extent.

Chemistry through a well-developed industry is adding a gigantic force to the war effort. Any one of the major items would constitute a most impressive contribution by itself. The total effect can not, of course, be accurately evaluated because no one group of materials can be said to be more essential than any other, when all must be supplied in sufficient quantities in order to win the war. The billions of gallons of synthetic hydrocarbons for motor fuels, the billions of pounds of aluminum, the billions of pounds of powder and high explosives, the great quantities of fertilizers, the production

of military gases, will without question play a role second to none in the production phase of our war effort. These enormous industries are possible only because of fundamental studies in thermodynamics, organic reactions and the reduction of these basic investigations to commercial practice by the chemists of this country.

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The Role of Botany in War-Time

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The requirements of war are specific and intense. This has, in the past, led to rapid scientific and technological advances which might have taken place much more slowly under the erratic stimulus of the profit motive or of leisurely curiosity. For example, tough-minded cultures which place little value on the comfort and well-being of humble individuals in civil life may be extremely businesslike and thoroughgoing in conserving the health and effectiveness of soldiers. The Romans were not noted as patrons of science, but they took good care to support the scientific work of military surgeons.

The expanding scope of modern total warfare and its growing complexity of operations have increased its demands upon science. Since the days of Napoleon it has been evident that the ultimate greatness of a commander rests in part upon his capacity to sense the possibilities of scientific counsel. No competent geographer would have sanctioned the march on Moscow—in fact Napoleon did not even take his staff into his confidence in planning this fatal project, thereby putting himself into the same despicable class as the client who tries to deceive his own lawyer. Napoleon also rejected what appears to have been a workable submarine.

The expanding scope of modern total warfare has widened the possible applications of science beyond the field of operations to the very periphery of life behind the lines. The National Academy of Science, established during the presidency of Lincoln for its advice in prosecuting the Civil War, was expanded into the National Research Council during the First World War. That this latter organization shows signs of strain during the present conflict may be inferred from the fact that by no means a high proportion of our scientific men are being used directly in the war effort as scientists, and from the further fact that a bill has been introduced by Senator Kilgore of the Military Affairs Committee to establish an Office of Scientific Mobilization.

I mention this background for a purpose. As compared with physics and chemistry, the war-time applications of biology are not conspicuous, and those of botany (if we except bacteriology, which is a botanical subject) are not so evident as those of zoology. Yet it would be extremely imprudent to dismiss botany as having little significance in the present emergency.

During the First World War, Professor John M. Coulter of the University of Chicago, sat as a botanist with the National Research Council. I heard him say once that his chief duties (and he was not overburdened) had to do with the identification of certain plants, among them members of the mint famiily which might be used as a source of the essential menthol and thymol which had previously come from Europe. Another American botanist, Dr. George Nichols of Yale University, a specialist on mosses, busied himself with a study of the kinds of Sphagnum or peat moss suitable for surgical dressing. In the British Isles this sphagnum problem was of such importance, due to the

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scarcity of cotton, that one Irish woman botanist was made a Dame of the British Empire in recognition of her services.

There was also, during the First World War, a regiment of foresters whose officers, and many of whose enlisted men, were trained botanists. This regiment was charged, among other things, with harvesting the pine forests planted long ago on the Landes of Gascony. The staffs of many agricultural colleges were strained to supply field workers to eradicate barberry, alternate host of wheat rust, and to check the spread of white pine blister rust.

How are botanists being used during the present war? I know of two who are commissioned in the air force to supervise preparation of airfield runways with sod covers which will prevent erosion. The botanists of the department of floriculture at Cornell are conducting classes in camouflage. One of the great rubber companies employes at least two botanists who are working on cotton fiber problems. Numerous botanical problems in plant breeding and acclimatization, disease control and metabolism have arisen with respect to the various rubber plants. The demand for rotenone for insect poison has been intensified by the scarcity of metallic spray materials, and the search for high-rotenone yielding plants must continue. These are concrete examples of war-time botanical projects under way—not merely things which might be done. I have reason to believe that the attitude of local draft-boards, not sufficiently conversant with the importance of such work, has deprived the public of young men of talent and training who are badly needed for work of this type.

One particular instance comes to mind of a well-trained student who was offered work in charge of rubber-plant culture by responsible agencies, but whose board would not release him.

In the field of military staff work botany is likewise of importance. The activity in Polynesia, where men must subsist in the midst of unfamiliar surroundings, has led to the compilation of a report on important food and poisonous plants by an eminent authority on the plants of that region. It is likewise essential that military staffs take into account the character of natural vegetation in the far-flung theatres of war, since this profoundly modifies the tactical procedures. Jungle fighting has its own requirements, just as forest and prairie warfare had theirs in the days of the American frontier.

One of my students, now an officer of marines, spoke to me of his work in plant ecology. He said that it gave him a tremendous advantage in minor tactics, since it had trained him to analyze terrain by means of the vegetation present. I quote an interesting comment: "It seemed to me that most of the other cadets had ridden automobiles all their life without looking to see what was on the other side of the barbed-wire fence along the road." His skill could easily mean life instead of death to himself and the men under his command; success instead of failure in a mission.

I am obliged to assume that the military authorities are cognizant of these matters, which are technically known to them as "terrain appreciation." At any rate I twice offered my services to officials of the General Staff, once before and again after Pearl Harbor, only to be assured that they had at hand adequate help. One letter specifically mentioned "ecologists."

However, it is probably in the civilian background of war that botanists have the most to offer. Food has always been the basic munition; without

commissary, field kitchen, and emergency rations the most powerful weapons become useless. Clothing and shoes are of almost equal importance. Moreover, the increasing use of plastics, organic explosives, and synthetic fibers makes an additional and growing demand upon the production of plant materials. Fundamentally, such production is the task of applied botany.

There are many factors which the food producer cannot control. But, with adequate assistance from botanically trained sources, he can control the quality of plant protoplasm which he puts into the ground. It takes no more labor to tend a crop that has the proper genetic make-up than to grow one of inferior heredity, and the difference in results is vital in time of national stress.

This can be illustrated vividly in the case of cotton. There is today the greatest need for cotton fibers of maximum length and strength. Fifteen years ago the head of a great agricultural institution in the South told me that one of the most serious sources of waste under his observation came from the thoughtless planting of cotton seed which would produce fiber of indifferent length and strength. Yet in the intervening years so little progress has been registered that the selection and development of suitable strains is now an important war-time concern of at least one great firm of tire-manufacturers, which, by any reasonable standards, has enough on its hands without this additional responsibility.

Certainly war-time needs in a nation which is heavily charged with the production of raw materials give no excuse for relaxing any of the fundamental and applied work on economic plants in our experiment stations and extension services. Pathologists, geneticists, horticulturists, agronomists, foresters, all must have every reasonable facility in the way of equipment, funds, and personnel. But this is not enough. There is another function of the trained botanist which even in time of peace has received too little recognition and encouragement, and which under the strain of war is even more essential.

I refer to the function of the ecologist, whose special knowledge of plants and environment give him a unique place in the planning of proper land use and management. It is generally conceded that the serious wind-erosion of the 1930's was the direct consequence of ill-advised planning, against which specialists had protested as early as 1915. But so little was the importance of this kind of knowledge understood that one good friend of mine nearly lost his job for suggesting that reckless plowing of grassland to grow wheat was bound to cause trouble.

A few years ago I was informed by the representative of farm organizations in one of the grassland states that the ecologist in his experiment station had done immeasurable benefit by his studies of range and pasture management. That ecologist's position became vacant and was offered to a young friend of mine, very capable, but physically disqualified for military service. As in the earlier case I mentioned, his draft board refused to release him for this kind of work, although both army and navy had rejected him. He was first asked, "Who in Hell wants a biologist?" and later ordered "to get into something productive." It is only thanks to his own enterprise that he is not filing castings or driving rivets, rather than rendering service along botanical lines, as he now is.

I trust I have shown you that the question is not "Can the botanist be useful in war-time?" but "Will we give him the chance to be useful?" Let us remember that the advice of a good geographer might have prevented the fatal march on Moscow more than a century ago.

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Geology in the Present War

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Geology and geologists play an unspectacular but none the less vital part in modern warfare. Modern war is a war of machines and machinery. Geologists are those who probe the earth's crust in the search for ore minerals and fuels. These are the substance of a modern war machine without which a tank or bomber or battleship could not be built, and once built it would be impotent without an adequate supply of fuel. The role of the geologist in modern war is threefold: (1) he locates, investigates, and aids in the development of raw materials; (2) he studies and maps land forms; (3) he serves as a member of the armed forces.

RAW MATERIALS.—At the beginning of the war we in America were quite complacent in the conception that we had a controlling interest in the world's mineral resources. And, in fact, the overwhelming majority of the proved reserves of economic minerals was controlled by the United Nations group and by friendly neutrals. This was strikingly true in the case of such resources as petroleum, tin, nickel, and others. Large reserves of fuel occurred in the United States, British and American controlled fields in Iran and Iraq, the Dutch East Indies, and friendly neutrals located to the south of the United States. Abundant tin reserves were under Dutch, French, and British control in the Malay Peninsula and the East Indies. Nickel and cobalt are extensively mined in Canada, molybdenum in the United States, commercial diamonds in South Africa, mica in India and Madagascar. These and a long list of others were virtually controlled by the United Nations group. Such resources as iron ore and coal occurred abundantly in both camps, and the largest supplies of others, such as the Spanish mercury, were located in unfriendly neutrals. The axis nations themselves had a controlling interest in few mineral resources at the outset of the war.

After Pearl Harbor the strategic mineral situation changed radically and rapidly. Axis nations, particularly Japan, occupied important mineral-producing areas affecting the production of tin, petroleum, and other products. The rapid expansion of war industries in this country caused shortages formerly unsuspected. In some instances this shortage was relieved by expanding production and processing facilities, as in the case of magnesium, for example, where an abundant source of raw material lay close at hand in our large dolomite deposits and oilfield brine. In other cases, such as aluminum, our proved reserves of high-grade ore represent only a few years' supply; therefore, extensive search for new deposits is being carried on. Still other shortages were caused by the technologic advancement of modern warfare. An outstanding example of this type of shortage is quartz crystal, now obtained largely from Brazil and needed in much larger quantities than ever before in radio and electrical equipment for the Army and Navy. Other shortages

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caused by increased use have occurred in copper, zinc, iron, tungsten, vanadium, manganese, and to a lesser extent in many others.

These shortages are being met in one of four ways: (1) by exploration for new or formerly unknown deposits of ore minerals and extension of known deposits; (2) by substitution of an abundant material for a scarce one; (3) by utilization of low-grade ores; and (4) by development of supplies in neutral countries. Most of these jobs are being carried on by the federal and state geological surveys and the Bureau of Mines, in cooperation with special war agencies, such as the War Production Board and the Board of Economic Warfare. Some typical examples of this work are: the greatly increased production of mica in North Carolina as imports from India and Madagascar decreased; discovery of new bauxite reserves in Arkansas and development of processes for extracting aluminum from high-alumina clays; development of cinnabar (mercury ore) deposits in Arkansas, California, and elsewhere; development and importation of larger quantities of tin ore from Bolivia and Alaska; utilization of clay products and plastics as substitutes for metal products; substitution of silver for copper in some electrical equipment; extraction of zinc and other metals from lower grade ores than formerly used; and so on.

The mineral fuels—coal, oil and gas—are of vital importance in modern warfare; they are food for the industrial machine. We have heard of gas and oil shortages in various parts of the country, and rumors of coal shortages that may appear in the future. These shortages are a different type from those discussed above. With the exception of certain types of motor fuel they are not as yet gross national shortages, but are local shortages caused by increased demands in some areas and inadequate transportation facilities to supply these areas. The task of the geologist in this case is to locate additional supplies near the points of consumption and thus relieve in part the transportation burden. Thus, natural gas produced in West Texas or the Hugoton field of Kansas is of little help in relieving a shortage in eastern Kansas once the existing pipe-lines are operating at maximum capacity. This general picture is not likely to change with respect to coal and natural gas. In the case of petroleum, however, with a declining rate of discovery of new reserves it may be that another year of war will bring us into proximity with a gross national shortage. The geologist will then again have the problem of finding oil wherever it occurs within our borders.

Study of our coal resources is largely carried on by the various geological surveys and the Bureau of Mines. Oil and gas exploration is largely done by the companies themselves, with the public agencies making regional or correlating studies and furnishing general services.

Domestic water supplies represent still another type of shortage because they vary not only from place to place but from time to time. Also an abundant supply of water may not possess the proper chemical characteristics for the intended use. Regardless of other favorable features, a war plant or military base must have an adequate water supply in order to exist. This problem is of particular importance in a state such as Kansas where, over large areas, surface streams are inadequate and water for such establishments must be obtained from wells. The federal and state geological surveys are

the primary organizations investigating ground-water problems over the United States for the Army, Navy and other agencies.

MAPPING.—The preparation of certain types of maps is largely carried on by geologists. The Alaskan Branch of the Federal Geological Survey has made reconnaissance maps of many thousands of square miles of territory for the Army Air Forces. Geologists are used to interpret aerial photographs for the Air Corps. Topographic engineers and geologists employed by the Federal Survey and the War Department have made detailed contour maps of coastal and strategic war areas in many parts of the United States. Still other types of maps, including data on topography, mineral resources, and water supplies of foreign areas, have been prepared for the Army. The making of maps is a basic task that must precede most successful military operations.

SERVICE IN THE ARMED FORCES.—Many geologists are serving directly with the armed forces. They are performing a wide variety of tasks depending on the particular theater of operations and the type of action.

Water-supply work has been an important type of geologic service in the armed forces. This includes exploration for water supplies and their development for use both at semi-permanent bases in foreign territory and for temporary bases in arid and semiarid regions. Major Richard Cady, our friend and former Geological Survey colleague in Nebraska, was killed a few months ago while engaged in this type of work in Eritrea. A number of ground-water geologists who were formerly employees of the United States Geological Survey are now serving in foreign theaters of operation on water-supply work.

Geologists serving with the Army Air Forces study and interpret aerial photographs, both from the standpoint of preparing reconnaissance planimetric maps and compiling geologic data that might have some bearing on the effectiveness of bombing fortifications and other land emplacements. Geologists are also used in the preliminary stages of the construction of air bases in foreign territory.

The Engineer Corps of the United States Army utilizes the services of a few geologists in foreign fields, although to a lesser extent than the British, Russian, and German armies. They are useful in the planning of strategy where operations are influenced by topography, boggy terraine, dune sand, or other special land forms that would create an impediment or advantage to a moving army. Conditions of bedrock are important in the planning and construction of permanent fortifications, and in trench warfare, the operation of listening devices, emplacement of mines, and many other operations.

Some geologists with special training or experience in geophysics are being used by the Navy.

CONCLUSIONS.—Thus, during wartime the geologist plays a stagehand's role; in the oil fields and mines, industrial plants, planning of strategy, and in actual combat operations.

PAPERS OF SPECIAL NOTE DEALING WITH THE GEOLOGIST AT WAR

BROOKS, ALFRED H. Use of geology on the Western Front: U. S. Geol. Survey, Prof. Paper 128-D, pp. 85-124, 1920.

BUCHER, W. H. Bibliography of military geology and geography: Geol. Soc. America, December, 1941.

CRONEIS, CAREY. Geology in war and peace: Am Assoc. Petroleum Geologists, Bull, vol. 26, no 7, pp. 1221-1249, 1 fig., July, 1942.
CROSS, WHITMAN. Geology in the World War and after: Geol. Soc. America, Bull., vol. 30, pp. 165-188, March 31, 1919.
JOHNSON, DOUGLAS W. Battlefields of the World War: Am. Geog. Soc., Research Series no. 3, 1921.
JOHNSON, DOUGLAS W. Geology and strategy in the present war: Geol. Soc. America, March, 1940.
MOORE, RAYMOND C., and JOHNSON, DOUGLAS W. The environment of Camp Funston with a chapter on the western theater of war: Kansas Geol. Survey, Bull. 4, 81 pages, 1918.
PENROSE, R. A. F., JR. What a geologist can do in war, J. B. Lippincott Co., Philadelphia, 28 pp., 1917.
PRICE, PAUL H., and WOODWARD, HERBERT P. Geology and war: Am. Assoc. Petroleum Geologists, Bull., vol. 26, no. 12, pp. 1832-1838, Dec., 1942.
SIEGRIST, MARIE, and PLATT, ELIZABETH T. Bibliography of military geology and geography, first supplement: Geol. Soc. America, January, 1943.
SMITH, H. T. U. Aerial Photographs And Their Applications, Chapter XIII, Military Application, D. Appleton-Century Co., New York, 1943.
WILSON, ROBERT E. Petroleum and the war: Am. Assoc. Petroleum Geologists, Bull., vol. 25, no. 7, pp. 1264-1282, July, 1941.

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Relation of Zoology to the War Effort

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Although the biological sciences have not been drawn upon so extensively as have the physical sciences, zoology can and does serve the war effort in manifold direct and indirect ways. In wartime as in peacetime, the biological sciences express themselves less in machines and factories and more in backgrounds, such as nutrition, disease control, pest control, and the like.

DIRECT MILITARY APPLICATIONS

Among the direct military uses of zoology may be mentioned the breeding of carrier pigeons, training of sentry dogs (of which we hope to have about 7500 by the end of the year, as compared to an estimated 50,000 in Germany), breeding of test animals for biological standardizations, growing of spiders for webs for cross-hairs on optical equipment, management of animals in the veterinary units of the service. Among the first of the WPB priorities was that on down feathers, since the entire supply available at the time was needed for the equipment of army units that were to serve in the far north. A recent issue of *Life* (1) describes a fishing kit with which to equip rubber life rafts. Two of the *Smithsonian Institution War Background Studies* (2, 3) deal with "The Natural-History Background of Camouflage" and "Poisonous Reptiles of the World" respectively. Much is being said about biological warfare. Metcalf has recently expressed the opinion that "Rats infested with fleas and infected with bubonic plague could be released in a besieged fortress, city or island and would probably provide a conflagration of disease and death vastly more devastating than any raid of bombing planes, landing of parachute troops, bombardment with long-range guns, or even the use of poison gases." (4) Although somehow we shudder at the thought of such methods of warfare, we must take a realistic view. We must not be caught unprepared. Should our enemies see fit to start biological warfare, we must be sure we shall be able to give more than we take. Incidentally, it is not generally known that wild rats infested with the bubonic plague flea *Xenopsylla cheopis* (Roth) have been found in Kansas and many other western and midwestern states, or that more than twenty species of native rodents may act as carriers for the flea (5).

NUTRITION

It is in the field of nutrition that zoology has some of its most important responsibilities. We are again hearing "Food will win the war!", even as we heard it during World War I. Food, especially meat, is not something that can be produced indefinitely and at will. Careful planning is essential and expansion of production is necessarily slow. Since this symposium includes an entire paper on food, I shall mention only a few of the zoological backgrounds of the problem. From this viewpoint, it is not enough merely to demand expansion of production and to set the approximate goals. There must be recommendations and aids for handling the problems of substitute

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feeding, crowding, transportation and disease prevention, to mention only a few. To this end, *The Inter-Associated Council on Animal Diseases and Production* has been at work since early 1942. This Council, consisting of representatives from The American Veterinary Medical Association, The Poultry Science Association, The American Society of Animal Production, The American Dairy Science Association, and the United States Live Stock Sanitary Association, works in close cooperation with The National Research Council and other interested organizations (6). Many problems not ordinarily very serious become critical in time of food shortage. For example, it has been shown that pushing too hard with heavy protein foods cuts down the productive life of a dairy cow. Extensive studies are under way to determine the supply of meat available in the form of reindeer and other large northern mammals. The rabbit assumes nutritional importance of such a degree as to encourage research in production instead of extermination. Suddenly the entire country wants more fish, for the army, for lend-lease, for home consumption; perhaps we can use some of the heretofore "useless" forms, such as some of the sharks. As a result of the alarming decrease in the Scandinavian supply of Vitamin A, the high vitamin content of the shark liver becomes an item of importance. The dogfish had already been sold as food to some extent (under the name of "grayfish"); the name "shark" may be somewhat of a handicap from the standpoint of marketing.

PEST CONTROL

Control of undesirable animals becomes particularly important in wartime. Our armed forces are operating in some twenty tropical countries, where they come in daily contact with parasites and diseases which are rare or unknown in our own country. The details of this great problem, as well as that of insect control, have been presented in other papers in the symposium, so I shall omit them. The birds are significant in national defense—"No medals were handed out, but the British Ministry of Agriculture recently gratefully cited the army of insect-eating birds that put in long hours last summer in protecting British crops and making a magnificent harvest possible. Protective laws have increased Britain's insectivorous birds to record numbers" (7).

The principle illustrated by the above quotation is of wide application. It is more important than ever now not to destroy the beneficial predators; badgers, hawks, snakes, toads, etc. They are our willing allies; they help to reduce the heavy tax we pay to the insects, rodents and other pests, and to increase our food production at a time when such increase is critically needed.

JUNGLE WARFARE

The protection of the soldier in foreign territory that is markedly different from our own requires, among other things, some knowledge of the animal life of the region involved. A recent issue of *The Readers Digest* lists the following from the files of The Medical Intelligence Division of The United States Army: "poisonous sea snakes", "clams as big as meat platters which can grab a swimmer's foot with a bear-trap grasp", "leeches so voracious that they can produce anemia in a short time", "bats infested with rabies", "rivers are contaminated with disease-bearing flukes" (8). The opening statements of The War Department's *Basic Manual for Jungle Warfare* are: "In jungle warfare the soldier fights two enemies; man and Nature. Of the two, Nature

is often the more formidable". About half of the book deals with the problems of getting along with Nature. Beebe has discussed in a recent popular article (9) the identification of harmful and beneficial animals, the detection of poisonous plants by noting the reactions of native animals to them, and other similar problems. Most of us who are zoology teachers have by this time received letters from former students who are now in military service in the jungles, letters testifying to the importance of knowing what animals can safely be handled and used for food and which ones are harmful or dangerous. Not even the thoroughly neglected taxonomy appears entirely useless in wartime zoology.

INDIRECT AND LONG-TIME RELATIONS

A number of indirect and long-time zoological problems are brought into sharp focus by the emergencies growing out of the war. How far can we go, without doing irreparable damage, in the depletion of breeding stocks of, for example, the Arctic seal, which all at once becomes highly important for its fats and leather? What shall we do about the protection of such specialized breeders as the Pribiloff seals? The principles of conservation, of careful use and management of our wildlife, and of ecological succession do not change just because there is a war going on. The conservation program is even more important to a nation at war, however. But we obviously do not have the facilities or the manpower to carry on all the activities at their peacetime pace; to what extent and in what directions shall we let the program slip? Flocks and herds will have to be rebuilt in Europe, and while they are being rebuilt, a flow of meat, eggs, dairy products and other foods will need to be maintained. To what extent and in what ways should our present management practices be modified and adjusted to meet the future needs?

THE BIOLOGY TEACHER

It is perhaps not out of place in a symposium of this sort to call attention to the contribution which the biology teacher can make to many of these problems. In his hands is the dissemination of information in such fields as nutrition, protection of birds and other valuable predators, heredity and superman myth, the general principles of the relations of animals to their environment, and many others of like importance. That the biology teachers of the nation are alert to their opportunities and obligations in this regard is shown by the *National Defense Issue* of the official journal of The National Association of Biology Teachers (10) and the many other contributions in subsequent issues of this magazine.

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Let me close with a quotation from an editorial in a recent number of Nature Magazine: "For example, the preservation of two or three hundred birds may seem—and is—of infinitesimal importance compared with the preservation of American freedoms, yet the Army has acted to preserve the last of our trumpeter swans, a remnant of which now exists in Yellowstone National Park and the Red Rock Lake National Wildlife Refuge. An artillery range was planned at Henry Lake, on the flyway between these two areas. The birds would almost certainly have been destroyed by practice bombardment. The Army, however, chose an alternative and equally satisfactory site when the facts were pointed out.

To a country where such a viewpoint exists there can come nothing but victory. Nazis, Fascists and Japanese fanatics would never be able to understand this principle. And for this reason they are doomed to defeat." (11)

REFERENCES

1. Fishing Kit. Life, Vol. 14, No. 9, p. 82, March 1, 1943.
2. FRIEDMANN, HERBERT. The Natural-History Background of Camouflage, Smithsonian Institution War Background Studies, No. 5, Pub. No. 3700, 1942.
3. COCHRAN, DORIS M. Poisonous Reptiles of the World: A Wartime Handbook, Smith. Inst. War Bkgd. Stud No. 10, Pub. No. 3727, 1943.
4. METCALF, C. L. The Importance of Insects in War Times, The Science Teacher, Vol. 10, No. 1, p. 7, 1943.
5. GRUNDMANN, A. W., BOLES, H. P., and ACKERT, J. E Plague Flea, Xenopsylla cheopis in Kansas, Tran. Kan. Acad. Sci, 44.38, 1941.
6. JAKEMAN, H. W. The Production of the Meat, Milk, and Eggs to Win the War and the Peace, Science, n. s. 97(2515): 244, March 12, 1943.
7. Contents Noted (Editorial). Nature Magazine, Vol. 36, No. 2, p. 63, Feb. 1943.
8. RATCLIFF, J. D. The Army's Health Spies, Readers Digest, Jan. 1943, Condensed from Collier's, Oct. 17, 1942.
9. BEEBE, WILLIAM. How Lost Jungle Fighters Can Survive, Popular Science, Vol. 142, No. 3, p. 49, March 1943.
10. National Defense Issue, The American Biology Teacher, Vol. 4, No. 7, April 1942.
11. Symbols of Our Freedom (Editorial). Nature Magazine, Vol. 35, No. 2, p. 89, Feb. 1942.

Some Contributions of Psychology Toward the War Effort

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Three decades ago psychology was thought to be good only to teach, but about a year ago, the War Manpower Commission listed psychology along with medicine and engineering as an occupation having critical value for the war effort, the pursuit and study of which entitled one to occupational deferment. A discussion of how these changes came about and the use of psychology in placing men in the armed services is the object of this paper.

Psychology received national recognition for the first time at the beginning of World War I when psychologists were placed in the Sanitary Corps in the Office of the Surgeon General for the purpose of finding and eliminating the feeble-minded from the army. At that time several psychologists persuaded the military authorities that they were qualified to do this work and were equipped to do it better than medical men, psychiatrists, or any other group of professional men. After having convinced the military authorities that they might be able to do something, a rather long period of experimentation and investigation followed, the result of which was the making of tests for the measurement of the intelligence of soldiers. The authorities who observed and studied the results of the preliminary tests were so pleased with the results that they considered the intelligence score of an individual to be the most important single item of information that was obtained about him. After this preliminary investigation and experimentation, psychologists were given a regular place and a specific type of work in the army organization.

Already at the beginning of World War I, some instruments had been developed for the measurement of intelligence; tests for the measurement of individual intelligence had been standardized and developed to a high degree of perfection. Psychology was also in a period of rapid transition from a study of the individual's consciousness by the method of introspection to the study of behavior by objective methods, the purpose of which was to make psychology practical and useful for doing the day's work. In fact, one outstanding psychologist said that the goal of psychology was the prediction and control of human behavior. This new type of psychology lent itself readily to the practical uses demanded by the army. At the end of the war, psychology had made itself far more useful than was first anticipated. Besides finding and eliminating the feeble-minded from the draftees, psychologists obtained an intelligence rating on every soldier and officer in the army. A group test was devised which was used for measuring several hundred soldiers in the same length of time that previously had been used in measuring the intelligence of a single individual. There were two types of these group tests; one was called Army Alpha, used for measuring the intelligence of those who could read and write, the so-called literates. The other, Army Beta, was a group performance test independent of language and was used for measuring the intelligence of illiterates. About thirty per cent of the enlisted men were unable to read and

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write well enough to take Army Alpha and so had to take Army Beta. During the present world war this percentage has been reduced to less than ten.

The following uses were made of the score obtained by the administration of intelligence tests:

1. Rejection of feeble-minded
2. Selection of candidates for officers
3. Selection of various superior men for doing unusually difficult tasks
4. Balancing companies with respect to intellectual ability
5. Selection of candidates for developmental battalions. These consisted of men who were unable to take military training as offered to the average soldier, but could be trained to be effective soldiers by the use of special methods
6. The devolpment of proficiency tests for measuring the degree of skill in each of a hundred or more occupations
7. The discovery of the use of intelligence tests for the occupational placement of the men

It would be difficult to say which of these was the greatest worth to the services. Probably it would be the use of tests for the finding of good officer material; but the value of others, for example balancing companies, should not be overlooked. Before the use of intelligence tests some companies contained as high as 13 per cent of men of unusually superior intelligence while other companies contained less than four per cent of men of this caliber. This factor made for unequal fighting ability of different companies; but after they were balanced for intelligence, the fighting capacity of all the companies was approximately equal. Neither should the development of proficiency tests be overlooked. Previous to the use of these tests, soldiers who claimed to be good truck drivers were shipped to France to carry out the work of their choice; but when they arrived on the field of action, they were found unable to do the work. Errors of this sort were eliminated to a large extent by the development of proficiency tests for measuring skill in different trades.

At the close of the war, psychologists recorded their main achievements in a very voluminous report and then returned to their institutions to conduct business as usual. Military psychology was forgotten and left to the Germans to develop to a high degree of proficiency during the inter-war period. Although psychologists for the most part returned to their former work, some of them were employed by industry and business to engage in the work of human engineering, or so-called personnel work, the object of which is to find the right man for the right place and to make everybody happy in his work so that he would stay on the job. Because of this activity, applied psychology made great advances during the time of peace. Other psychologists developed new testing techniques and new tests, not only for the measurement of intelligence but also for the measurement of various aptitudes. The employment service of the government employed a great many psychologists who developed personnel and interview methods to a high degree. At the beginning of the second world war in Europe, psychologists suspected that the war might eventually come to America and accordingly appointed an emergency committee to prepare psychology for such an event. This committee was appointed in September, 1939; and by the time of the entrance of the United States into the war, it had developed new and better tests for military purposes.

When the United States entered the second World War, psychology had much more to offer the government than it had at the beginning of the first world war. In spite of the lack of attention to military psychology during the inter-war period, the military forces could now draw from civilian life a number of men who were able to give technical help, for personnel men engaged in government employment service could be used for similar work in the army; and in addition, personnel men employed by business and industry could be drawn upon. Research centers where testing and statistical techniques had been developed to a high degree were also available. There were also available a number of clinical psychologists who had become skillful in solving problems of maladjustment, as well as numerous specialists in educational tests. The military authorities were not slow to recognize the value of these possible services, and therefore gave psychology a better place than previously in the organization of the army. These psychological services were placed in the Classification and Enlisted Replacement Branch of the Adjutant General's Office. In this position, psychologists could effectively do their work and found authority for executing their decisions. The army, however, is only one of the branches of the government that uses psychologists. Other services that make use of the profession are the Navy Department, the Marine Corps, Department of Commerce, Department of Agriculture, Department of Justice, Department of Labor, United States Civil Service Commission, Federal Works Agency, Federal Security Agency, Federal Communications Division, the Coordinator of Information, the Office of Facts and Figures, the Office of the Coordinator of Inter-American Affairs, Tennessee Valley Authority, Library of Congress, the National Advisory Committee for Aeronautics, and the National Roster of Scientific and Specialized Personnel. The fact that so many services use psychologists is in itself adequate testimony of the practical value of psychology and calls for the employment of many professional psychologists. The number of psychologists now employed by the various governmental services is not exactly known; but it is estimated to be one-fourth of the total number in the United States, or about 850.

What are the present uses of psychologists? Probably their most important work is the classification or placement of men in activities for which they are best qualified and in which they may be of the greatest service to the country, but they do many other types of work besides this. They devise techniques for the effective training in the skills required in military work. They measure public opinion and attitudes for the purpose of finding out how well governmental programs are acceptable to the public and how they may be changed to make them more acceptable. They devise techniques for building up civilian and military morale and propaganda efforts. Their efforts are not limited to activities which may be said to have military value. They are also interested in techniques which are of special value to the civilian population; for example, handling and dealing with children in bombed areas and solving problems of how to care effectively for war orphans. In this work, the objective is to relieve children in bombed areas of the effects of shock and fear and to find new homes for orphans in which they may again have the feeling of security and happiness.

In as much as classification is one of the most important types of work, I wish to give some details about this work in the army, which is also typical of

that done in the navy and the marine corps. It is of interest to civilians since their sons come in direct contact with this work; in fact, what your son or mine does in the army is largely determined by the classification given by psychologists. After an inductee goes to an induction station, enters the medical building and removes his clothing, the first person that he meets is a psychologist who sizes him up and inquires about the extent of his education. If he finds that he has completed less than the fifth grade of the elementary school, or if he is not engaged in employment outside of the control of his immediate family, or if for any reason he is thought not to be self supporting, he is drawn out of the line and sent to an examining room where he receives an individual mental examination to determine whether or not he is feeble-minded. During the summer of 1942 I had the good fortune of doing this type of work at Fort Snelling. The results of my experience there are probably typical of all induction stations in the northern states. At Fort Snelling, approximately four per cent of the inductees were selected for individual mental examination; about half of those selected, or two per cent of the total inductees, were found to have such a low degree of mental capacity that they were judged to be unfit for military work. In this work we used tests that were nearly independent of language, since many of the subjects were illiterate. In view of the investment the government makes in every soldier, this initial elimination of the unfit is an immense saving.

If the inductee is not feeble-minded and passes his physical examination, he then is ready to receive a number of more advanced tests. Among these are the General Classification Test given to all normal literates. For the illiterates, there is a so-called Visual Classification Test, which takes the place of Army Beta in World War I. The normal literates are also given a number of special ability or aptitude tests for special types of work such as mechanical tests, clerical skills, operating a radio telegraphic machine, learning the telegraphic code, and ability in combat. Among the latter there are some specialized tests used to determine whether a given individual should be a pilot, gunner, or navigator in a bomber.

Nearly all of the above tests are given at the reception center. The results obtained determine the training center to which the soldier is sent. If during the basic training the soldier shows any unusual aptitudes for special types of work he is given further tests to determine his proficiency for other work. One of the most important of these is the Higher Intelligence Examination given to men who show possibilities of becoming officers. From the replacement center, the soldier is either sent to officers candidate school or to a suitable tactical unit in which his work for the army is to be done.

A word may be said to explain how these tests were secured. They were made in specialized research units which employ highly trained technical men to do this work. The methods used by them were very technical and are not easily understood except by technical men, but suffice it to say that it takes a number of months to make a test and that it is not used until it has extensive try-outs and its practical value proven. For example, before the first army intelligence test was used it was tried out on over 80,000 men.

The results of test scores as well as many other achievements are all recorded on a so-called officers qualification card. This card accompanies the soldier wherever he goes and at the close of the war will be sent back to the

soldier's nearest employment office where it will be used to place him in proper civilian employment. Besides the test scores of the soldiers this card contains the individual's personal history, his home address, his educational history, his vocational and business history, his military history, a record of his special interests and achievements, and a record of all skills that he possesses. If he can play a cornet or operate a typewriter or repair a radio or preach a sermon or do any other skill, all is recorded on this card. Whenever men of certain qualifications are required, a search is made through the qualification cards. The men having those qualifications are selected to do the work required. After the war, this card will be returned to the soldier's nearest employment agency and used to find him a civilian job.

Relation of Entomology to the War Effort

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In the other world war the entomologists, by their knowledge of insect control, increased production of food supplies, prevented losses of materials in storage and assisted in the protection of man and animals from insect-borne diseases. In this war they will do the same, but this time we are confronted with a much more gigantic task in the field of medical entomology. Our men are widely scattered in tropical regions where many of the most serious diseases, such as malaria, yellow fever, dengue fever, relapsing fever, typhus fever, typhoid fever, plague, verruga Peruviana, sleeping sickness, Chagas disease, filariasis and other parasitic disturbances, are transmitted by insects or their relatives.

In all of these diseases the recognition of the particular kind of insect or other arthropod that carries the disease, a knowledge of its habits, and methods for its control are important, for the elimination of the vector or carrier is in many cases the only way to stop the spread of the disease. This is a job for the man trained in medical entomology. We entered this war as short of men trained in this field as we did in mathematics, physics and chemistry.

Not only were there surprisingly few young men trained in medical entomology but there had been a neglect of both medical entomology and parasitology in the medical schools of our country and both of these subjects are fundamental to an understanding and control of tropical diseases.

The problem, therefore, of safeguarding the health of our fighting forces in the far-flung tropical lands confronted us *without* a sufficient number of medical entomologists and without doctors whose training had prepared them for work with tropical diseases.

The army has commissioned a good many entomologists in the sanitary corps. Of the first eight entomologists to receive commissions, three of them were K.U. graduates and these three are majors now. One of them is somewhere in the Pacific, another is in charge of all insect control work in the Fourth Service Command, which includes 90% of the malarial work at military camps in this country, and the third man is training sanitary officers and men at Camp Robinson. These Kansas men had had some course work in medical entomology but went into the army from civilian positions where they were concerned with the control of agricultural insect pests.

The majority of the entomologists commissioned were without practical field experience in medical entomology but fortunately there were a few who had been employed by the U. S. Public Health Service or were specialists in the identification of the Diptera (flies, mosquitoes, etc) which is the most important order of insects from the standpoint of vectors of disease. One of our boys who was in the U. S. Public Health Service was commissioned in the army and within a week was flying across the Atlantic to take up malaria con-

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trol work in North Africa. Another one of our men spent a year teaching medical entomology to doctors who were to go on foreign service. He is now on his way to serve in the Far East.

Both the army and navy have training schools where they are teaching various phases of insect control. The doctors are given training in medical entomology as preparation for their work with tropical diseases. Those in the sanitary corps are being trained in insect survey and control work. Even the Army School for Bakers and Cooks is learning to identify and control cockroaches and other insect pests of stored foods. Thus within the military organization they are attempting to train men for special entomological assignments but are still looking for men with some foundational training in entomology.

The control of insect-borne diseases in the areas surrounding military camps and in war industry centers has increased the need of the U. S. Public Health Service for entomologists. They had some 50 entomologists this winter but need many more for the summer survey and control program. Where these are to be obtained, I do not know. Those properly trained and urgently needed have been commissioned as officers in the U. S. Public Health Service.

This unforeseen demand for medical entomologists is due to our army occupation of widely scattered tropical lands abroad, our lack of quinine at home, and the dangers of spreading insect vectors of disease by our greatly increased air transports.

Insect-borne diseases have played a part in other wars. Typhus fever has had a major role in many wars. Doctor Zinsser says, "In most major wars of the past more persons have succumbed to typhus than have fallen on the battlefield." It was serious in the last world war. Typhus fever is transmitted from man to man by lice.

Under trench warfare of the first world war, the louse problem was bad. Under such conditions and in civil populations under war conditions, the louse population becomes great and typhus fever, which lice carry, becomes serious. In the last war, among the Russians, there was a 20% mortality—2,000,000 Russians died of typhus. The children that survived that epidemic are helping fight Russia's battles today and are immune to typhus.

It has been demonstrated that great losses from typhus need not occur in modern warfare. In the Italian campaigns in Abyssinia in 1935, while there were 20,000 cases of typhus among the Abyssinian troops, there was not a single case among the Italians because of the rigorous cleanliness enforced. An army without lice will be an army without typhus.

While Europe has been the principal center of the great typhus epidemics of the world, in the past ten years there have been outbreaks in all the countries of North and Equatorial Africa, in Asia Minor and in the mountainous parts of British India and adjoining countries.

Delousing units should accompany our troops in any of these places. So far in this war malaria, yellow fever and filariasis have been our chief concern, all of them mosquito-borne diseases. Malaria is caused by a tiny one-celled animal that lives in the red blood corpuscles of man. It is transmitted from one man to another only by the bite of certain kinds of mosquitoes that belong to the genus Anopheles. When a man having malaria is bitten by one of these Anopheles mosquitoes, the disease-producing organisms are sucked up with

the blood and in the mosquito they undergo a development and form tumors or cysts on the stomach of the mosquito. In each cyst there develop a great many tiny elongate organisms that finally break out of the cyst and migrate to the salivary glands from which they are ejected by the mosquito when it bites another victim. The development within the mosquito requires from 10-12 days. Therefore, after the mosquito has bitten a man having malaria, it is ten days or more before it can give the disease to another man. If there were no Anopheles mosquitoes, there would be no malaria.

For example, there are no Anopheles mosquitoes in Hawaii, Tahiti, Fiji, Samoa, and the Marquesas Islands in the Pacific and there is no malaria on these islands. But in most of the tropical and semi-tropical world, including the Solomons and New Guinea, and over many more temperate regions, Anopheles mosquitoes abound. More than 300 species of Anopheles have been described and, since every species tried experimentally (some 73 of them) has proved a vector of malaria, all Anopheles must be looked upon with suspicion. However, in any one locality there is usually only one or two species that are the major vectors of malaria there. Since every species has its own preferential breeding place, it is first necessary to identify the species responsible for the spread of malaria in the locality concerned and then direct control measures against that mosquito. All mosquitoes breed in water and most people recognize mosquito wrigglers when they see them in the water. But some Anopheles wrigglers prefer standing water, some want flowing water, some shady pools, others sun-lit pools; some want plenty of aquatic plants present, others do not; a few breed in the water of tree holes, cocoanut shells or bamboo stems. So the control of the malaria-carrying mosquitoes depends upon what species it is.

In Trinidad, where we have acquired military bases, malaria is the outstanding health problem. One of our entomologists found that one of the vector mosquitoes there breeds in the water which collects in the leaves of a plant growing on trees, so malaria there is not confined to areas of marsh and stream but found at all altitudes and we are confronted with a new control problem.

Usually the control of mosquitoes involves drainage, the proper handling of impounded waters and the use of oils or Paris green on the water. But each new land we enter with our troops presents a special problem that requires an entomologist skilled in the determination of mosquitoes and familiar with the habits of the species concerned.

In this country the shortage of quinine has thrown the burden of controlling malaria back upon mosquito control. The U. S. Public Health Service has some fifty entomologists on the malaria mosquito control problem. These men are working in defense areas to help keep the war production going. We have considerable malaria in the South—from 1,000,000 to 6,000,000 cases a year. While the death rate outside the tropics is only 9 per 1000, the economic loss is staggeringly high. The loss of efficiency caused by malaria in a country is beyond comparison greater than that caused by any other disease. Doctor Herms says that one death from typhoid or tuberculosis corresponds to 500 sick days, which are work days lost, whereas one death from malaria corresponds to from 2000 to 4000 work days lost.

In the tropics the death rate is much higher—1 per 100 or 1% in India,

which is the largest of the malaria countries. They estimate 1,000,000 deaths a year from malaria in India. In parts of Africa the infected population runs above 90%. Already malaria has played its disastrous part at Bataan and along the Burma Road. In the Solomons, Doctor W. W. Gist, formerly of Kansas City, reports that on Guadalcanal "75% of the entire complement contracted malaria at one time or another with 4% out of action at any one time."

In some areas we find Anopheline species that make better hosts for malarial organisms than others. In this country in a malarious community where *Anopheles quadrimaculatus* is the carrier, you may find only one or two specimens out of a hundred females harboring the malarial parasite, whereas in Brazil, where the African *Anopheles gambiae* was brought probably by airplane, 23% of the females of this species were infected. This African species is the most efficient vector of malaria known. It has now been wiped out of South America after it had invaded 12,000 square miles but it is a dangerous species in Africa.

To prevent further introductions of mosquitoes or of tsetse flies from Africa to South America, all planes are disinfected before being unloaded. Similar precautions are taken with the planes coming from South America to the United States and from places that harbor malaria and yellow fever mosquitoes to places that do not. The entomologists have this responsibility.

In west Africa thirteen species of mosquitoes belonging to four or five genera transmit yellow fever, and tsetse flies, which are found only in Africa and Arabia, carry the dreaded sleeping sickness. The spread of any of these disease vectors might prove disastrous and insect surveys and sanitation measures are being taken at transport landing fields.

In this war, insect-borne diseases present a more serious problem than in any previous war; hence the need for men with entomological training.

On the home front, besides malaria, we have the threat of relapsing fever, plague and endemic typhus. Moreover, we have to feed our fighting forces, our war industry workers and undertake to help a considerable bit of the world besides. The birth control of pigs and the fear of over-production of food crops has been replaced by the fear of under-production. Agriculture is facing a shortage of manpower. This means that we must prevent insect injury to the crops that are grown to get maximum yields for the labor expended. This is a service we must render general agriculture. Then there are the problems of the Victory gardens. Garden insects destroy a larger portion of the crops they attack than do the field crop insects and, with an increasing number of inexperienced people planting gardens, the calls upon entomologists for help considerably increase their work.

Under plans as they now stand, there is no program to replace the 750 entomologists drawn into the armed forces or to train young men to serve as economic entomologists to help protect the crops from destruction. We can, however, offer courses in insect control to larger numbers of such students as we have so that they can use this knowledge on the home front and increase food production. In the last war our classes in applied entomology were the largest we ever had and it ought to be true in this war for we are faced with the problem of feeding a considerable portion of the world. Moreover, in this war both medical entomology and parasitology should be required of medical or pre-medical students as background for tropical medicine.

There is also the storage problem. When foodstuffs are stored, we always have severe losses from insects. Sometimes transportation problems make unusual delays in moving grains and processed food supplies and under such conditions insects do an abnormal amount of damage. There is always the necessity of concentrating large stocks of food stuff when armies are to be fed and this increases the danger of damage from insects. The treatment of such products requires the experience and training of an entomologist who can identify the species causing the trouble and handle the poisonous gases used in fumigation operations. One lieutenant colonel said recently that he urgently needed men with this training and experience.

Then there are always insect problems that become big problems under war conditions. The concentration of large civilian populations in centers of war industry brings with it a number of entomological problems. In many places, the housing facilities are entirely inadequate, people live in crowded conditions, with a great increase in the bedbug problem and the increase and spread of lousiness. The lack of heat under such conditions always increases the louse problem and where there are body lice, there is the threat of typhus fever. In defense areas, where thousands of people are living in trailers, we have, in the summer months, the problem of sanitation. If there is inadequate sewage disposal, the housefly may carry typhoid fever and dysentery and if the area is in the South, we have the problems of other insect-borne diseases. People "camping out" in trailers are more likely to be bitten by mosquitoes and therefore more apt to contract malaria and dengue fever. They are also more apt to be bitten by ticks which carry spotted fever and endemic typhus.

In addition to reducing the number of insect carriers of disease, attention is being given to pest insects such as the pest mosquitoes. Even if these mosquitoes do not carry disease, they reduce efficiency by disturbing rest and by taking valuable time from work to swat them. Where thousands of men are employed, the loss of five minutes each day by each man means a considerable loss and it has been found profitable to spend money in mosquito and dog fly eradication.

This war has certainly presented the entomologists with plenty of problems. Many of the insecticide materials used in insect control are vital in war industry and other largely used insecticides, like rotonone and pyrethrum that we have heretofore imported, are hard to get. Rotonone comes from plants grown in the East Indies and in South America, but the Japs have the East Indies and it will take time to develop the South American production. Pyrethrum, which was practically a monopoly of Japan, now is produced in large quantities in Kenya, Africa, but the lack of shipping makes it scarce here. In 1941 we used nearly 13,000,000 pounds of pyrethrum (7,215,000 pounds allotted for 1943). Already search is being made for new insecticides to take the place of those we can no longer get. In May of this year it was announced that Thanite, a substance obtained from turpentine and pine oil, can be used in the control of many insects where we formerly used pyrethrum and rotonone.

Moreover, some of our colleagues upon whom we depended for determination of material have been permitted to resign for war work and if this war is a long one, young women will have to be trained to take over the identification of mosquitoes and other trouble-making insects and to handle the rear-

ings in the experimental laboratories. If our colleges would emphasize courses in beginning and applied entomology, the knowledge of insect control would be more widely distributed and this would be helpful in increasing the food supply. Already plans are under way to build up a supply of men with at least a little training in medical entomology, but no definite program has been set up to train personnel in general insect control and if the production of food supplies becomes critical, we will certainly need entomologists. Doctor L. O. Howard, who was for many years Chief of the Bureau of Entomology at Washington, has said that "the labor of a million men each year is lost through the destructive action of insects in this country." This has been our problem with insects in peace time. Now that we are at war, that million men is needed elsewhere and there must be entomologists to see that the losses from insect depredations are greatly reduced.

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